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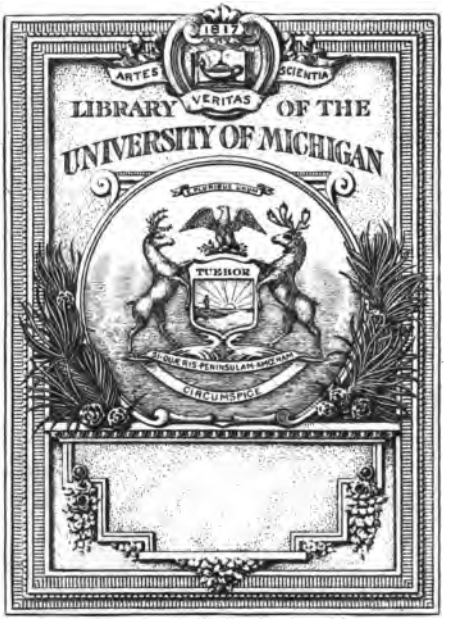
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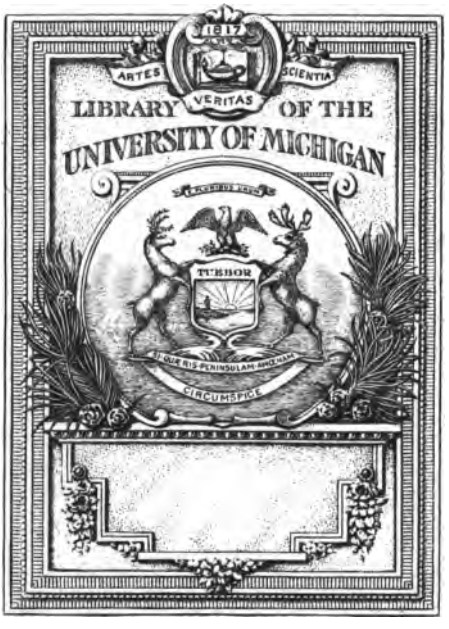
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A

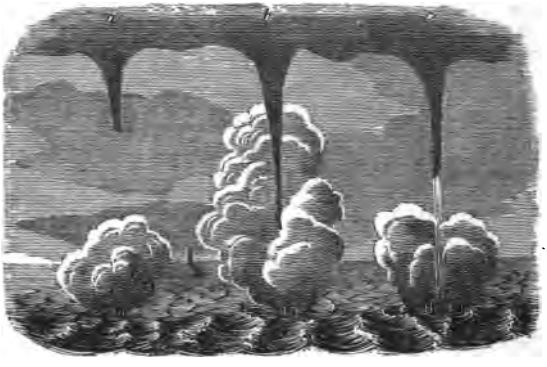
TREATISE

ON

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

INTENDED FOR

THE USE OF SCHOOLS, ACADEMIES, AND GENERAL READERS.



BY J. L. COMSTOCK, M. D.

AUTHOR OF "MINERALOGY," "NATURAL PHILOSOPHY," "CHEMISTRY," "BOTANY," "GEOLOGY," "PHYSIOLOGY," etc.

HARTFORD.

PACKARD AND BROWN.

1837.

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PREFACE.

The subjects which come within the scope of Mathematical and Physical Geography, are so numerous and extensive, that the author found much difficulty in selecting those which are most important to the student, and in condensing them within the compass of a school volume.

Physical Geography alone, in its widest sense, would include a natural history of the Globe, embracing an account of the changes which its surface has undergone; together with a description of all its animals, and productions, whether vegetable, or mineral, considered in relation to latitude, longitude, and climate. But it is obvious, that a volume of moderate size, including all these subjects, would contain nothing more than a synoptical view of each, and therefore must exclude those explanations, which learners require, and thus defeat the object of our labors—the instruction of youth.

The author, therefore, has selected from this variety, such subjects as he thought would be most useful to the pupil, and has given such explanations to each, as seemed requisite to make them readily understood. This course was thought preferable to that of touching upon a greater number of subjects, and leaving the student ignorant of causes, or circumstances, necessary to be known, in order to comprehend the inferences, or facts, to which they lead.

For example, the spherical form of the earth, is the fundamental principle of all Mathematical Geography, and the author, in the usual manner of writing School Books on such subjects, might have assumed that this is its form, or have quoted, in few words, various authorities, to prove that this is the case. But the intelligent pupil, in the present advanced state of education, is not, nor ought he to be, satisfied with a bare statement of philosophical truths; and hence, the author, as a preliminary step to finding the true form of the earth, considered it necessary to explain the manner in which a degree of the meridian is measured—

why the different lengths of a degree, in different latitudes, prove that the earth is an oblate spheroid—and also, on what principle the different rates at which a clock moves, in different latitudes, indicate the same form.

Thus the pupil becomes acquainted, not only with the facts, but also the grounds on which they are founded, and is enabled to reason, and judge for himself on the subject, and if called upon to do so, can explain to others, in what manner the true figure of the earth has been demonstrated, beyond all controversy.

In like manner, all that it is necessary for the pupil to know, with respect to latitude, and longitude, and the methods by which they are found, are explained in the most familiar terms—also, the causes which have produced the oblate form of the earth—the manner in which plants have been disseminated—how islands have become inhabited by the human species—the means by which the quantity of sediment in river water, is determined—how the images of ships in the air may be accounted for; and generally, whenever explanations are required for the full comprehension of the subject, they have been given.

The author is fully aware, that the publication of a volume on Mathematical and Physical Geography alone, as a school book, and this, too, without either Maps, or Charts, is an experiment; but had he not been convinced that such a work was wanted, in order to supply a vacancy in the course of education, in our country, this volume never would have been written.

With respect to Maps, every family, containing school children, has already an abundant supply, and therefore, the publication of a new series, would have increased the price, without the least advantage to the students of this treatise.

This volume is intended, not only for the use of such scholars, as having gone through the usual course of Geography, desire to extend their knowledge of the Physical History of the Earth; but also, for such general readers, as have not time, or disposition, to examine the great variety of sources, from which its contents have been derived.

Such as it is, the author now submits it to the public, but not without the hope, and even expectation, that it will prove an acceptable, and useful addition, to the sources of knowledge, already in the hands of the youth of his country.

HARTFORD, CONN., FEBRUARY, 1837.

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A TREATISE

ON

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

Definitions. The term "Geography" is derived from the Greek, and signifies a description of the Earth.

Geography is divided into three distinct departments, namely, Mathematical, Physical, and Political.

MATHEMATICAL GEOGRAPHY, is that department which points out the methods by which the form and size of the earth is demonstrated, and its artificial lines, circles, and divisions are fixed—also, the means by which latitude, and longitude are found, and the relative position of the earth in the system of the Universe is determined. The annual, and diurnal revolutions of the earth are likewise subjects belonging to this department.

PHYSICAL, OR NATURAL GEOGRAPHY, has for its objects a description of the principal features of the earth's surface, and its natural boundaries, whether by water, or mountain, also a knowledge of the internal structure of the earth,—of its several climates, and different productions, and how these are affected by different causes.

POLITICAL, OR CIVIL GEOGRAPHY, describes the in-

What is the meaning of the term geography? What is mathematical geography? What is the object of physical geography? What is political geography?

habitants of the earth, and shows the artificial boundaries of Nations, Kingdoms, States, and Towns, including an account of the Religion, Government, Learning, and general condition of their inhabitants.

In this Treatise, our attention will be occupied only by the two first divisions, Mathematical and Physical Geography.

PART FIRST.

MATHEMATICAL GEOGRAPHY.

GENERAL FORM OF THE EARTH.

In the application of mathematical principles to Geography, the first object will be to ascertain the form of the Earth, for on this will depend in a great measure, the truth, and success of our future inquiries, and investigations.

If the earth is a vast plain, as was formerly supposed, or a cylinder, and not a sphere, then all our artificial divisions, as zones, lines, hemispheres, and parallels, have no foundation in truth, and all our suppositions based on the presumption of such a figure, are not only worthless, but are fit only to perpetuate the most glaring errors.

Proofs that the Earth is a Globe, or Sphere. The proofs that the earth we inhabit, is a sphere are various, and therefore require several divisions.

First, *The appearance of distant objects on the Earth's surface.*

Second, *The different positions of the same stars when observed from different parts of the Earth.*

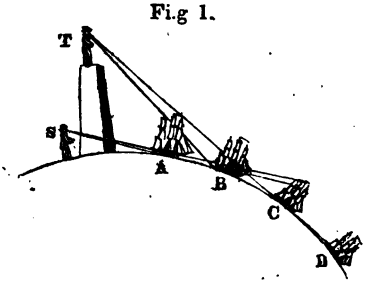
What is the first object in the application of mathematics to geography? Suppose the earth to be a vast plain, how would our present divisions into zones, &c. apply to it? What are the circumstances which prove that the earth has a spherical form?

Third, *The shadow of the Earth on the moon during eclipses.*

First, *The appearance of distant objects on the Earth's surface.* It is well known to those who have been at sea, or have stood long enough on the shore to witness the approach, and arrival of a distant ship, that not the hull, but the top masts, and upper sails first appear in sight. The low parts are hid by the spheroid surface of the water, which rising up between the spectator and the ship, intercepts his line of vision, and therefore to see the whole he must wait until the ship passes over the intervening rotundity, in her approach towards him, or must overcome the obstacle by seeking an elevation proportionate to the distance of the ship.

Suppose the ship to sail directly away from the spectator, situated at S, Fig. 1, then the whole would continue for a time in his view, in the direction of the water line A, and he would continue to see the hull until it reached the point where the vault of the heavens, and surface of the water apparently meet, or to the extent of the *visible* horizon at B.

Fig 1.



But when the ship reaches C, the hull will entirely vanish, the upper sails only remaining visible, as seen by the direction of the visual line to the eye of the observer.

If now the spectator will quickly ascend a higher station, as at T, he will increase his extent of visual horizon, by placing himself above the spherical protuberance of the sea, which before intervened between him and the object, and thus again be enabled to behold the whole of the ship, as indicated by the straight line, T, D.

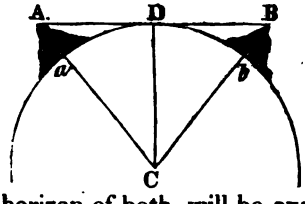
How do the appearances of objects on the earth's surface show its spherical form?

If now the observer descends from his elevation he losses sight of his object entirely, though the distinctness of the last glimpse is sufficient to prove that it was not the actual distance, but only the interposition of a segment of the ocean, in consequence of his descent, which still prevented his seeing the entire object.

Size of the Earth found by the heights and distances of two stations.—If we measure the exact heights, and distances of two stations on the surface of the earth, which can only just be observed from each other over the earth's convexity or edge of the horizon, we can thereby ascertain the size of the earth itself; and were it not for the effect of atmospheric refraction, which is greatly increased at the surface, and by which we are enabled to see in a degree around, or over the interposed segment of the earth, this would be by far the most simple and easy method of finding the great and important problem, the size, and form of the earth.

As an illustration of this principle, suppose A and B, Fig. 2, to be two eminences, whose perpendicular heights A, *a*, and B, *b*, (which for simplicity we will suppose to be exactly equal,) are known, as well as the exact horizontal interval *a*, D, *b*, by actual measurement; then it is clear that D, the visible horizon of both, will be exactly half way between them; and if we suppose *a*, D, *b*, to be the section of a sphere of the earth, of which C is the centre, then we know, D, *b*, the length of the arc of the circle between D and *b*, namely, half the measured interval between them; we also know the height of B, above the surface of the earth. By these data an easy geometrical problem would enable us to find the length of the radius, or semi-diameter of the circle D, C.

Fig. 2.



If, as we have supposed both heights are equal, and their distances inconsiderable in comparison to the size of the earth, which of course must be the case, the solu-

tion alluded to may be found by the following proposition, viz.

The Earth's diameter bears the same proportion to the distance of the visible horizon, from the eye, as that distance does to the height of the eye above the Sea level.—Herschel's Astronomy.

Now although the effect of refraction prevents this from being an exact method of finding the dimensions of the earth, allowing it to be an exact sphere, yet it will serve to illustrate this part of our subject, and at the same time show an approximation to the results of more exact methods to be described hereafter.

It appears by observation that two objects each ten feet above the surface of still water cease to be visible from each other at the distance of eight miles under common atmospheric refraction, this invisibility being caused by the spherical form of the earth alone. On the above data, Sir J. Herschel gives the following formula for determining approximately, the size of the earth.

"Now 10 feet is the 528th part of a mile, so that the one half of this distance, or 4 miles, is, to the height of each station, as $4 \times 528 = 2112$ to 1, and therefore in the same proportion to 4 miles, is the length of the earth's diameter. This diameter therefore, by the same rule, must be equal to $4 \times 2112 = 8448$, or in round numbers about 8000 miles, which is not far from the truth."

Second, *The different positions of the same stars when observed from different parts of the Earth.*—When we change our position on the surface of the earth, going from north to south, we find that many stars in the northern hemisphere, pass in succession below our field of vision, while others towards the south, not before visible, come into view. Thus the *polar* star gradually rises as we approach the north, and sinks as we go towards the south.

Now the stars are at such vast distances from us, that were the earth a plane, their positions would not suffer

---

What is the second proposition by which sphericity of the earth is proved?

any appreciable change by our movement from one extremity of it to the other, since the angle produced by a base of such extent, would be too small to be measured by any means in our possession. Even, the annual revolution of the earth, making a difference with respect to the distances of the fixed stars, equal to the whole diameter of the earth's orbit, or 190,000,000 of miles, makes no visible difference in their distances, or places.

The apparent places of the stars would therefore be no more effected by a change of position equal to the earth's diameter, or 8000 miles, than those of the sun, or moon would be, by looking at them from different windows of the same room.

Therefore, were the earth a plane surface, or a cylinder, lying in the direction of north and south, the polar star would be at the same apparent elevation, whether the observer approached or receded from it, and consequently its depression as we go south, and its elevation as we approach the north, must be caused entirely by the spherical form of the earth, of which the appearance and disappearance of the ship, as she approaches and recedes from the spectator, is an illustration.

Third, *The shadow of the Earth on the moon during eclipses.*—Eclipses of the moon are caused by the interposition of the earth between the sun and moon, and by which a shadow of the earth is cast upon the face of the moon.

The dark part of the moon's face, at such periods, is nothing more, therefore, than a representation of the earth's shadow on her disk.

Now, in whatever position the earth happens to be at the time of an eclipse, still its shadow on the moon is always in the form of a circle. The earth must therefore be a sphere, since no other form, in every position, with respect to another body giving light, would cast a circular shadow on the third body.

Explain how the different elevations of the north star proves the earth's rotundity? How are eclipses of the moon caused? How does the shadow of the earth on the moon, show the form of the earth?

It is true, were the earth shaped like a wheel, flat and circular, it would, in one position, cast a round shadow on the moon, but in other positions, the shadow would be elliptical, or if turned edgewise, the shadow would be nothing more than a dark line across the moon's disk. But as eclipses happen during every position of the earth's surface with respect to the moon, and as the shadow never varies from a circle, there is sufficient proof from this circumstance alone, that the form of the earth is that of a sphere.

Several other proofs, such as the uniform motion of the earth around her axis, and its circumnavigation by numerous voyagers, might be adduced in addition to these, but the proofs already considered are sufficient to show the earth's orbicular form beyond all doubt, or controversy.

Irregularity of the Earth's surface.—But it may be objected, that the earth cannot be a sphere since there are some mountains on its surface which rise to the height of three, or even five miles, and that these ought at least to show a corresponding shadow on the moon's disk.

But a moment's consideration will show that we might with equal propriety expect that the dust on an artificial globe would be discovered by its shadow on the wall, as that the inequalities of the earth would be apparent by her shadow on the moon.

Allowing the highest mountain to be five miles in perpendicular elevation, still this is only the 1600th part of 8000 miles, the diameter of the earth; consequently on an artificial globe of sixteen inches in diameter, such a mountain would be represented by a protuberance of no more than the one hundredth part of an inch in thickness, which is about equal to that of an ordinary sheet of drawing paper.

If therefore, we would construct a perfect model of the earth in the form of a globe of sixteen inches in

If the earth were in the form of a wheel, would it not make a round shadow? Explain this. What other proofs might be brought to show the earth's sphericity? On an artificial globe of sixteen inches, how large a protuberance would represent the highest mountain on the earth?

diameter, we must take care that its inequalities, or difference of elevation between sea and land, do not, with an exception, or two, exceed the thickness of common writing paper.

The highest planes on such a globe, would be represented by an addition of the thinnest tissue paper on the general surface, while the ordinary hills would be no higher than the smallest visible grain of sand.

THE EARTH AN OBLATE SPHEROID.

Having shown above, that the general form of the earth is that of a sphere, or globe, we are now to prove that its diameter is not equal in every direction, and therefore, that its figure is not exactly that which corresponds to the term by which it is generally designated.

Its figure however, differs so little from that of a perfect sphere as not to derange, or vitiate in the least any calculations, or conclusions we have heretofore drawn from it as such, and therefore a knowledge of its exact form must be considered only as the consequence of very minute investigations.

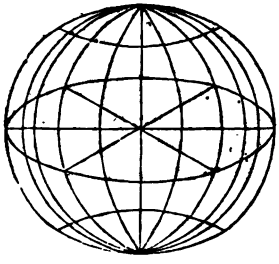
In order to determine as nearly as possible, the exact form of the earth, it has been necessary to resort to experiments of an extremely delicate nature, and to call in the aid of the most refined, and complex mathematical calculation, founded on the facts which such experiments have brought to light.

For many years the attention of the most eminent philosophers of Europe have been turned to this subject, and it is now settled, not only that the earth is an *oblate spheroid*, or is flattened at the poles, but also, that its different diameters are ascertained within a very few miles.

The figure called an oblate spheroid, is that of a sphere, flattened at its poles, or opposite diameters, as represented by Fig. 3, thus making the polar, less than the equatorial diameter.

What ought to be the thickness of other inequalities on such a globe? What figure is represented by an oblate spheroid?

Fig. 3.



Without giving the details of the calculations by which the difference between the equatorial and polar diameters have been very nearly ascertained, it will be sufficient for our present purpose to state, that the nearest, and most recent approximation to an exact result, is as follows:—

	Feet.	Miles.
Greater, or equatorial diameter,	41,847,426=	7,925.648
Lesser, or polar diameter,	41,707,620=	7,899.170
Difference, or polar depression,	139,806=	26.478

The proportion of these diameters is very nearly as 298, is to 299, and their difference therefore $\frac{1}{299}$, or a very little greater than $\frac{1}{300}$, which consequently, ought to be the difference in round numbers for common purposes.

By this we see that the number 8000, which is usually employed to indicate the diameter of the earth is considerably too large, but being a round number, may with propriety still be employed for common purposes.

Causes which have produced the Oblate Speroidal figure of the Earth.

In order to account for the present form of the earth, we must assume that it was once in a soft or semi-fluid state. In this case, provided the mass were at rest, its form, by the laws of attraction, would have been a perfect sphere. This may be illustrated by adverting to the well known fact, that all bodies in the fluid state, when left to themselves take this form. Globules of mercury

What is the actual difference between the equatorial, and polar diameters of the earth? What is the relative difference of these diameters? What state must the earth have been in, in order to account for its present form?

rolling over a dry surface; the fall of water through the air in the form of hail, and that of melted lead, which comes down from a height in the form of shot, are examples.

This form is evidently the consequence of the mutual attraction of the particles in the direction of the opposite diameters, the attractive forces meeting at the centre, so that all the particles are brought as near this point as possible. Under the direction of such a force it is plain, that no other figure except that of a perfect sphere could possibly result, provided the mass were undisturbed.

But in a body having a motion around its own axis the perfect sphere is not the figure of equilibrium, and therefore, if we assume that the earth took its existing form, while under its present rate of motion, which is undoubtedly true, then from all we know of the laws of motion, and attraction, as two forces acting simultaneously, its figure could have been no other than that of an oblate spheroid.

If a perfect ball of soft clay, or dough, be placed on a spindle, and the spindle set in motion, the relative diameters of the ball will soon be changed, and it will assume a form similar to that represented by Fig. 3; that is, the polar axis, or that portion of the surface nearest the spindle will be draw in, while the equatorial diameter, or that portion of the ball equi-distant from the poles will be thrown outwards, by which the diameter will be increased through the equator, and diminished through the poles.

Centrifugal Force.—The change in the form of the soft ball above described is the effect of the centrifugal force, which operates on every revolving body, and most strongly on those parts which are at the greatest distance from the centre of motion, because there the velocity is greatest.

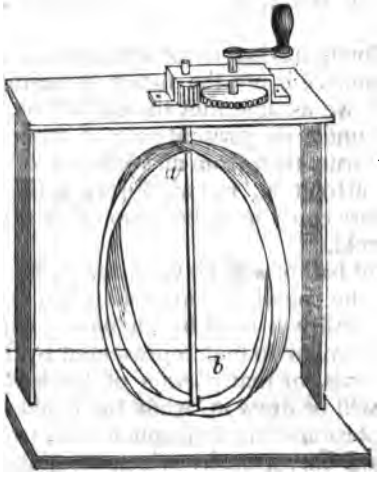
Why do undisturbed fluid masses take the figure of a perfect sphere? What figure would a soft body whirling on its axis take? What change of form will a soft ball undergo by making it revolve on a spindle? Where is the centrifugal force greatest, and where least, on a revolving body?

The centrifugal force, then, being in proportion to the velocity, increases at every step from the poles to the equator; because in revolving bodies, the velocity increases in proportion to the distance from the axis of motion.

This principle is sometimes very obviously illustrated by lecturers in the following manner.

Two hoops of thin iron are placed upon an axis which passes through their poles as shown by Fig. 4. The

Fig. 4.



axis *a*, *b*, is connected with wheel work, so as to give it, with the hoops a rapid motion. The hoops, before the motion begins, are circles, but when the motion is rapid, the centrifugal force causes them to expand, or swell at the equator, while they are depressed, or flattened at the poles, the two polar regions approaching each other at *a* and *b*.

Different degrees of Centrifugal Force on different parts of the Earth.

What is the centrifugal force proportionate to? How is this force illustrated by hoops? What are the different degrees of velocity on different parts of the earth?

The velocity of the earth, at the equator, in round numbers is 1000 miles per hour. Here, as we have already seen, the velocity is greatest, being at the greatest distance from the axis of motion, and for the same reason the centrifugal force is greatest.

From the equator, the velocity diminishes towards the poles at the following rates for every ten degrees of latitude.

Latitude.	Velocity per hour.	Latitude.	Velocity per hour.
Degrees.	Miles.	Degrees.	Miles.
0	1000	50	643
10	985	60	500
20	940	70	342
30	866	80	174
40	766	90	000

The annual motion of the Earth, has not effected its form.

As the earth has two distinct motions, one around her axis, and the other through her orbit, it might perhaps be expected that both would be considered in accounting for her present form.

But a moment's reflection will make it plain that since in the annual revolution, every portion, and particle of the whole mass moves with equal, and the same velocity, no effect on the form could be produced by this motion.

On the contrary, in the diurnal rotation, some parts move with great velocity, while others are nearly at rest, and it is this difference of motion which has accumulated the matter of the earth at the equator, and drawn it from the poles.

We might here go into mathematical demonstrations of the effect of centrifugal force on a soft revolving sphere, but the experiments with the ball of clay, and with the elastic hoops, already described, are perhaps a sufficient illustration of the manner in which the earth

Why has not the annual motion of the earth affected its form? What form is it said the diurnal motion of the earth must necessarily have produced?

has acquired its present form, and therefore it is only necessary further to state, that from the known laws of force and attraction, the present diurnal motion of the earth must necessarily have given it the form of an *oblate spheroid.*

ARTIFICIAL DIVISIONS OF THE EARTH.

For the purpose of description, the earth is supposed to be surrounded by several circles, which pass in different directions, and intersect each other at many points, and in various places.

These imaginary circles not only surround the earth, but some of them extend through the vault of the celestial sphere, or the concave of the heavens. Such are called *Great Circles*, as the *Equator* and *Ecliptic.* The *Lesser Circles* are the parallels of latitude and the polar circles.

HEMISPHERES AND ZONES.

The hemispheres are the two halves of the earth, on each side of the equator. They are called the northern and southern hemispheres.

There are five *zones*, Fig. 5, which divide the earth into as many parts from north to south. These are the Torrid zone, which extends to the distance of twenty-three degrees on each side of the equator. The north and south Temperate zones, each extend from the Torrid zone, to the polar circles, or to the sixty-seventh degree of latitude, and the Frigid zones extend from the sixty-seventh degrees of latitude to the poles. They are called the north and south Frigid zones.

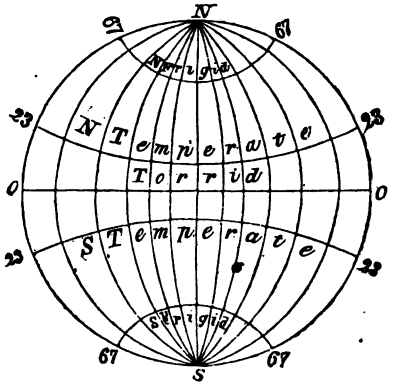
ZODIAC.

The Zodiac is a broad circle, or belt which extends

What are the great circles of the earth? What are the lesser circles? What are the hemispheres? How many zones are there? How far does the torrid zone extend? How far do the temperate zones extend? What parts of the earth are occupied by the frigid zones? What is the zodiac?

quite around the heavens. It is divided into two equal

Fig. 5.



parts by the ecliptic, or the sun's path through the heavens, on each side of which it extends eight degrees.

The Zodiac is divided into twelve equal parts, called the signs of the Zodiac. In this great circle the twelve principal constellations of the heavens are situated.

ZENITH AND NADIR.

The *Zenith*, or *vertex*, is that point in the heavens which is directly over our heads. *Nadir* is the point opposite to the zenith, and therefore that which is directly under our feet.

REVOLUTIONS OF THE EARTH.

The earth has a double motion, one on its axis called the *diurnal* motion, which causes the succession of day and night; and the other through its orbit, called its *annual* motion, which causes the vicissitudes of the seasons.

Diurnal Revolution.—It is well known to the pupil,

What are meant by zenith and nadir? What are meant by the diurnal and annual revoluions of the earth?

that it is in consequence of the daily revolution of the earth from west to east, that the sun, planets, and stars, have an apparent revolution from east to west.

The proofs that it is the rotation of the earth on her axis, and not the revolutions of the celestial bodies around the earth, which cause the succession of day and night, are entirely satisfactory, and may be found in almost every treatise on Astronomy. We shall therefore, take it for granted, without adverting to such proofs that the earth does make such a revolution once in twenty-four hours, or during a day and night.

Annual Revolution.—The annual revolution of the earth around the sun is performed once in a year; and it is this revolution, together with the inclination of the earth's axis to the plane of her orbit, which occasions the vicissitudes of the seasons, and the different lengths of the days and nights.

SOLAR AND SIDERIAL TIME.

There is a difference in the length of a day when the revolution of the earth is measured by a star and by the sun. A *tropical*, or *solar* year is the time occupied by the earth in making one complete revolution through her orbit, from one equinox, to the same again, which is equal to 365 days, 5 hours, and nearly 49 minutes.

A *siderial* year is the time occupied by the sun in performing a revolution from a fixed star to the same star again. This year is a little longer than the solar, the sun making his apparent revolution when measured by the star in 365 days, 6 hours, and about 9 minutes.

With respect to the diurnal difference, the stars appear to make their daily revolutions in 23 hours, 56 minutes, and 4 seconds, while the sun performs the same revolution in exactly 24 hours.

What phenomena do these two revolutions occasion? What is a tropical year? How long is a tropical year? What is a siderial year? How long is this year? What is the difference in time between a tropical and a siderial day?

Explanation of the difference.—To explain this difference, it must be remembered, that while the earth makes her diurnal revolutions, she is constantly advancing in her orbit, and therefore, that at twelve o'clock to-day, she is not precisely in the same position with respect to the sun that she was at twelve o'clock yesterday, or will be to-morrow.

Now the stars are at such vast distances from us, that the earth's orbit with respect to them is but a point, and therefore, as the earth's revolution is perfectly uniform, she revolves from any given star to the same star again, in precisely the same period of absolute time.

But the sun, as seen from the earth appears to arrive at the equatorial point, or the equator, a little before it comes to the same star with which it coincided the year before, when it crossed the equator.

These circumstances explain the difference in time, when measured by the sun, and by a fixed star; and the difference between the period of the sun's passing from one equinox to the same, and the period of his going from a given star to the same star again, is called the *precession* of the *equinoxes*, a subject which belongs to Astronomy, and not Physical Geography to explain.

DECLINATION OF THE SUN AND STARS.

The *declination* of the heavenly bodies, is their distances from the equinoctial line either north or south. The declination of the sun amounts to 23° 28′ both north and south during the year, so that the sun is alternately vertical at this distance from the equator annually, forming the Torrid zone, or the Tropics. For convenience we have commonly written the boundary of this zone, 23° instead of 23° 28′, which is the exact number.

The degrees of the sun's declination are found by observing his altitudes at the same place, as he passes the meridian, at the summer and winter solstices. Tables

Explain the reason why time measured by the sun and by a fixed differs? What is meant by the declination of the heavenly bodies?

of these declinations are constructed and published in nautical Almanacs, for the use of navigators in finding latitude.

MERIDIAN LINES.

Meridian, or *noon* lines, are imaginary circles passing through the poles, and thus dividing the earth from east to west. They cross the equator at right angles, and are the lines on which the degrees of latitude are marked. They are as numerous as the places at which observations are made.

Method of finding the position of a Meridian Line.—Many celestial observations required for finding the exact longitude, and latitude of a place, as well as for the solution of many other questions belonging to Mathematical Geography, make it necessary that the meridian of a place should be precisely determined.

The meridian line may be found by observing two equal altitudes of the sun, before, and after passing the meridian, that is, before and after twelve o'clock. But for this purpose it is necessary to select a day, on which the altitude of the sun is equal, at equal times before, and after passing the meridian, otherwise the constant changes which his declination undergoes will vitiate the result.

For this purpose therefore, a day must be selected when the sun is in the solstice, or when the days and nights are of equal length, which happens on the 21st of June, and on the 21st of December.

On these days, the altitude of the sun, at one, or two hours before noon, is exactly equal to his altitude at one, or two hours after noon,

To find the meridian, fix a rod on such a day, in an exact perpendicular direction to the horizon, as seen at

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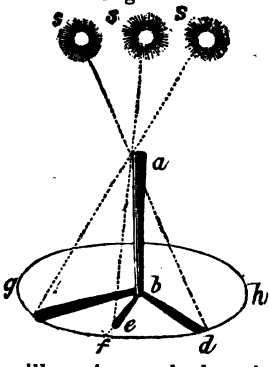
How are the degrees of the sun's declination found? What are meridian lines? In what directions do these lines divide the earth? In what direction do these lines cross the equator? To find a meridian line is it necessary to select a day when the day and night is of the same length

a b, Fig. 6. At precisely ten o'clock in the morning, mark accurately the extremity of the shadow at *d;* then from the base of the rod *b*, as a centre, and the length of the shadow *d*, as a radius, draw the circle *g h*, upon the ground, or upon a platform made for the purpose. Now as the sun gradually arrives at his greatest altitude, the shadow of the rod will become shorter and will be the shortest, *b e*, at twelve o'clock. After this, the shadow will again lengthen as the sun declines, and at two o'clock will again reach the circle, being then at precisely the same height in the west that it was in the east at ten o'clock.

Fig. 6.



Now as the sun has in these equal times, before and after noon, described equal spaces in the heavens, to, and from the meridian, therefore the middle point in the circle, between those touched by the shadows at ten, and two o'clock, will be the meridian of that place; hence if the arc between the two points where the two shadows touched the circle be divided exactly in the middle, which will be in the direction of the short shadow at *f*, then a line drawn from this point to the base of the rod will be the meridian line.

This simple method will answer for common purposes, but when a great degree of exactness is required, other and more complex methods are employed.

The longest meridian line ever drawn, is that on the pavement of the Church of St. Petronis at the city of Bologna in Italy. This is one hundred and twenty feet in length, and was made by the celebrated astronomer Cassini.

HORIZON.

The *visible* horizon is the boundary of vision, or the apparent meeting of the vault of the heavens, and the

plane of the earth in every direction around us. Hence the visible horizon is a circle in the centre of which the spectator stands. Each one therefore, has such a horizon peculiar to himself, and the centre of which he changes at every step.

The *rational* horizon is the great circle of the celestial sphere, coinciding, or parallel with the visible horizon. It divides the heavens and the earth into two equal parts, called the *upper and lower hemispheres.* The centre of the rational horizon is the zenith, from which it extends to the distance of 90° in a circle.

Means by which the precise form of the Earth has been determined.

Having made these explanations, we are now prepared to understand the methods by which the figure of the earth has as nearly as posssible been determined.

We have already shown that the general form of the earth is that of a sphere, and that its more exact figure is that of an oblate spheroid. We have also seen that this figure is the necessary result of the centrifugal force, caused by the earth's daily rotation.

All circles contain 360 *degrees.*—In order to understand what follows, the student must keep in mind, that every mathematical circle of whatever dimensions, is divided into 360 equal parts called *degrees.*

Now, if we can by any means determine the length of a single degree, we shall be able, by a very simple calculation, to ascertain the circumference, and the diameter of the whole circle, since by knowing the 360th part of a length, it is easy to find the whole.

In most instances, as in the manufacture of instruments, the circumference and diameter are first known, and the degrees then set off in their due proportions.

What is the visible horizon? Is the same visible horizon common to a number of spectators, or peculiar to each? What is the rational horizon? What is the centre of the rational horizon? How far does the rational horizon extend? How many degrees are there in every mathematical circle? How can we determine the length of the whole circle by finding that of a degree?

But with respect to the earth, to measure the whole circumference would be impracticable, and therefore, it was long since proposed to measure a degree, or the 360th part of the great circle of the earth, and from this to determine the circumference and diameter.

But as the earth has no land marks to direct the experimenter in such an undertaking, and show him that his course is along its greatest diameter, it became necessary that some celestial object should be selected for this purpose ; and accordingly a particular star was designated as a fixed point in the heavens, while a portion of a meridian line was the object of admeasurement on the earth.

A degree of the Meridian.—The meridian lines extend quite around the earth from south to north, or from north to south.

A degree of the meridian is that portion of it which must be travelled over, in order to change the altitude of any particular fixed star, by the 360th part of the imaginary meridian circle in the heavens.

To find whether the Earth is a perfect Sphere.—If the spaces travelled over, in different parts of the same meridian be unequal to each other, then it is proved that the terrestrial meridian cannot have the same curvature in every part, and therefore is not a perfect circle, and consequently, the earth cannot be a perfect sphere.

Necessary to measure several degrees.—It will be seen from the above, that in order to form data, on which the form, and size of the earth could be found, it is necessary that at least two degrees of a meridan should be measured ; for if the earth is protuberant at the equator, and flattened at the poles according to the theoretical views already detailed, then there would be a difference in the lengths of two such degrees, since the curve of the earth would be least at the equator, and greatest towards the poles.

What is meant by a degree of the meridian? How will measuring a degree of the meridian show whether the earth is a perfect sphere, or not?

But if the degrees proved to be of the same length from the equator to the pole, then it would be determined that the earth is a perfect sphere, and that all theory with respect to accumulations at the equator by the centrifugal force, would prove false.

The Earth proves to be flattened towards the Pole.—But it is found by actual trial, that to elevate the polar star by a quantity equal to a celestial degree, the observer must travel over a greater and increasing space, as he proceeds from the equator towards the pole.

Hence it follows that the degrees of a meridian line, or the degrees of latitude gradually increase in length from the equator to the pole, thus proving that the earth has less curvature at the pole, than at the equator, and therefore that it is flattened at the pole and not a perfect sphere, and hence it is shown that what was supposed to be true by theory, has been proved to be so by actual observation.

METHODS OF MEASURING A DEGREE OF THE MERIDIAN.

The first attempts to ascertain the length of a degree, were made by actual admeasurement, by means of the chain, in the manner employed by civil engineers for measuring roads at the present day. But this method was found too inaccurate to be depended on, and more recently, a combination of actual measurements, and trigonometrical calculations founded on them, have proved much more exact.

For this purpose two places, as principal stations are selected which lie under the same meridian, that is, are due north, and south from each other; the difference in the latitude of these two places is then accurately found, which gives the number of degrees and minutes between them.

A *base line*, of a few miles in extent, and at some

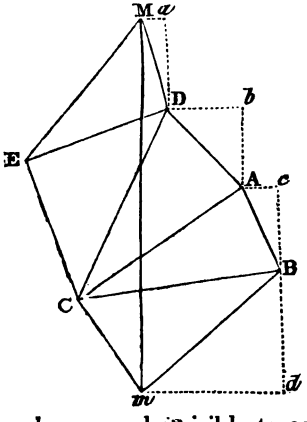
How was it proved that the earth is flattened at the pole? In what directions do the degrees of latitude increase, or diminish? In what manner were the first attempts made to ascertain the length of a degree? In what manner are degrees of the meridian measured at the present time?

little distance east or west of the meridian, is then measured with the utmost exactness, and this is the only actual measurement necessary.

The extremities of this line are connected with the extremities of the meridian arc by imaginary triangles. The sides of these triangles are not measured, but by the aid of the base line, and by means of the angles of the triangles, which are all ascertained by means of instruments; the distances from point to point, are determined by trigonometrical computation.

But this method will be better understood by the diagram, Fig. 7, where let M *m*, represent a meridian line between two stations; then the difference of latitude between *m* and M being found, the length of a degree will be the length of the whole arc, divided by the number of degrees contained in it.

Fig. 7.



To ascertain this length, a level plain is selected on which the base line A B, is measured, the two extremities of which are to be connected with the two extremities of the arc M *m*, by a series of triangles.

For this purpose convenient stations are fixed upon, such as may be visible to each other, as C D E. These stations are supposed to be connected with each other, and with the points M, *m*, by the imaginary lines which form the triangles A B C, B C *m*, A C D, C D E, and D E M. Then the angles by which the two stations, C and B appear to be separated from each other, when viewed from the station A, are observed. This observation gives the angle C A B, of the triangle A B C; the other angles of the triangle, are also observed, and determined in the same manner, and the side A B, which is the base line being known from measurement, the other two sides A C, and B C, may be computed by plane trigonometry.

By these means we obtain a side of each of the triangles B C *m*, and A C D, and are enabled to continue the process without measuring any more of the lines.

The angles of these triangles are measured as in the case of the first, and their sides ascertained in like manner by trigonometry; and by proceeding in this way, in the resolution of the whole series of triangles, the sides and angles are all determined.

From data furnished by these proceedings the length of the arc M *m*, is determined in the following manner.

From M and D, draw the lines M *a*, perpendicular to D *a*, parallel with the meridian line *d*, meeting each other at *a*; the lines D *b*, A *b*, A *c*, B *c*, *m d*, and B *d*, are also drawn so as to be respectively perpendicular with and parallel to, the meridian line. Then it will be evident that the length of M *m*, is equal to the sum of the lengths of *a* D, *b* A, *c* B, and B *d*, which are found thus:—the inclination of M D, to the meridian having been already determined by an astronomical observation, the angles D M *a*, in the right angled triangle D M *a* is known, so that D *a*, may at once be computed by trigonometrical tables. In the same way the sides *b* A, *c* B, *d* B, are computed, and the sum of the whole gives the length of the meridian arc M *m*, and the length of a degree is the length of the whole arc divided by the number of degrees contained in it.

Difference in the lengths of a Degree of the Meridian in different Latitudes.

The following table shows the length of a degree in various latitudes, according to the most recent and accurate measurements.

Latitude. °	′	″	Length in fathoms.	
0	0	0	60,480.2	Peru.
11	0	0	60,486.6	India.
45	0	0	60,759.4	France.
52	2	2	60,826.6	England.
66	20	10	60,952.4	Lapland.

Thus it appears as fomrerly stated, that the degrees

of latitude increase in length from the equator to the pole. The difference in the length of a degree at the equator and in latitude 66° north, is 472 fathoms, or 2833 feet, being about 200 feet more than half a mile. The average length of a degree, according to these five measurements, is nearly 69¼ miles, which being multiplied by 360, the number of degrees in the circle, gives 24,930 miles, as the circumference of the earth.

This is considerably more than the estimate formerly given, and in the present state of knowledge, no two results, even when made from similar data, are found precisely to agree with respect to the size of the earth. The average of a larger number of measured degrees would somewhat vary the result here given.

Means taken to secure accuracy in measuring a Degree.

The accurate measurement of a meridional degree being considered of great importance to general science, such undertakings have commonly been executed at the expense of governments, and therefore no expense has been spared in time, instruments, or skill, in order to ensure the greatest possible accuracy in the results.

Base Line measured in England.—The base line in the English measurement, the result of which is given above, was upon Hounslow Heath, in the county of Middlesex. It was five miles in length, and was measured by a steel chain of curious workmanship, constructed for the purpose. The same base had been measured before by Gen. Roy, with glass rods, and the results in the distance of the five miles differed only 2¾ inches.

The French base was measured with rods of platina, as being less affected by the vicissitudes of heat and cold than other metals.

That in Lapland was measured with rods of iron,

What is the difference in the length of a degree at the equator, and at 66 degrees north latitude? What were the means taken to insure accuracy in measurement?

allowance being made for their variations of length by change of temperature. In a previous measurement in that country made by the French astronomers, rods of wood were employed, because they are less affected by temperature than any of the metals.

Proof of the Oblate Form of the Earth by the Pendulum.

Although the form of the earth may be considered as determined by the means above detailed, yet the student in Physical Geography ought not to be unacquainted with the principles on which the Pendulum has been employed as a means of demonstrating the same result.

The Pendulum is indeed the most direct and simple means of testing the form of the earth, and the nature of this evidence may be explained by reference to principles which are understood by every student.

Effects of the Earth's rotation on Gravity.—The centrifugal force, caused by the earth's diurnal rotation, as we have already explained, is greatest at the equator, and least at the poles.

Now the centrifugal force acts in opposition to gravity, so that were the former force increased to a certain extent, that of gravity would cease entirely. The earth now moves at the equator, at the rate of 1000 miles per hour, and were this velocity increased to a certain rate, both fluids and solids would be thrown away from the equatorial regions, in the same manner, and for the same reason, that water flies from a wheel in rapid motion.

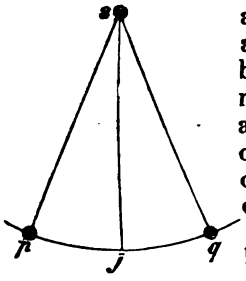
But though the velocity of the earth produces no such effects, it is still sufficient to produce an appreciable variation in the weight of the same body when removed from the equator towards the pole.

Now the pendulum of a clock performs its vibrations

Where is the centrifugal force greatest, and where least? How does the centrifugal force act on gravity? What would be the effect were the centrifugal force increased to a certain extent? By what force does the pendulum perform its vibrations?

in consequence of the action of gravity on the ball, or weight attached to the rod, and therefore, allowing the rod to be of a given length, the number of vibrations, will be increased in a given time by adding to the weight, and diminished by lessening it.

Fig. 8.



If two pendulums, *s p* and *s q* fig. 8, of the same length be taken and suspended from the same point, and *s j* be the vertical position of both, it is evident that they will move through the equal arcs, *q j*, and *j p*, in exactly equal times, because the force of gravity which causes their descent will operate equally on both.

But if one of these pendulums be made to vibrate at the equator, and the other at the city of Hartford, or at some other place between the equator and the pole, the time at which that at the pole will arrive at *j* will be shorter than that at Hartford, because the force of gravity which moves and accelerates both is greater at the pole, than at Hartford, or the equator.

But if we shorten the pendulum at the equator, it may be made to perform its vibrations in the same time as that at the pole, for it will then have to describe a smaller arc, and consequently a less accelerating force will enable it to describe the same space in the same time.

Such is the actual effect of gravity, or the centrifugal force, upon the vibrations of the pendulum in different latitudes.

Experiments with the Pendulum in different Latitudes.

It has been found by experiment, that if one, and the same pendulum, be made to vibrate in different latitudes, or, in other words, under different gravitating forces, and the number of oscillations made in the

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Why does a clock with the same length of pendulum move slower at the equator, and faster at the poles?

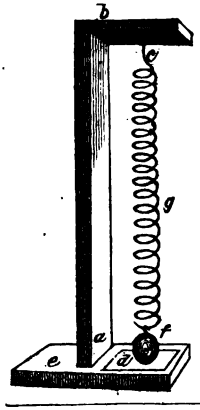
same time be counted, the intensity of the forces will be to each other, inversely as the squares of the number of vibrations made, and thus their proportions may be calculated.

For instance, it has been found by observation, that under the equator, a certain length of pendulum, makes 86,400 vibrations in a mean solar day, but when transported to London, the same pendulum makes 86,536 vibrations in the same time. Hence the intensity of the force urging the pendulum downwards at the equator is to that of London as 86,400 is to 86,535, or as 1 to 1.00315. In other words, a mass of matter at the equator, weighing 10,000 pounds, would weigh at London in latitude 51° 31′, 10,031½ pounds: or, in other words still, a steel spring would be bent by 10,000 pounds at London, to exactly the same degree that 10,031½ pounds would bend it at the equator.

Proposition to test the Weight of a Body by a Steel Spring.

Sir John Herschel has proposed to test the weight of the same body in different latitudes by means of a steel spring, in the following manner.

Fig. 9.



Let *a b c* fig. 9, be a strong support of brass standing on the foot *a e d*, cast in one piece with it, and into which fasten a smooth piece of agate *d*, which can be adjusted to a perfect horizontality by means of a level. At *c* let the spiral spring *g*, be attached, which carries at its lower end a weight *f*, polished, and convex below. The length and strength of the spring must be so adjusted that the weight *f*, shall be sustained by it just so as to swing clear of contact with

What are the proportions in which the same length of pendulum vibrates at the equator and at London? How is this expressed in other words, or with respect to weights? What is Sir John Herschel's proposition to test the weight of the same body under different latitudes?

the agate plate, at the highest latitude in which it is intended to use the instrument. Then if small weights be added, cautiously, it may be made to descend until it just grazes the agate, a contact which can be made with the utmost delicacy.

Let these weights be noted, the weight *f* detached, and the whole carefully packed for travelling. On removing towards the south, it will be found, that although loaded with the same weights as before, the weight *f*, will no longer have power to stretch the spring to as to produce contact with the agate plate as in the first experiment. More weights must therefore be added; and an additional quantity it is evident, will measure the difference of gravity between the two places.

Now suppose the spiral spring be so constructed that the weight of 10,000 grains, with its own weight, shall produce an elongation of 10 inches, then one additional grain will produce a further extension of the $\frac{1}{10000}$ of an inch, a quantity which cannot be mistaken in such a contact as that in question. Thus we should be provided with the means of measuring the power of gravity at any station to within the 10,000th part of its whole quantity.

The principal objection to this plan, and which seems to have escaped the thoughts of the writer, is the change of length in the standard, which would be produced by the vicissitudes of heat and cold. We would therefore propose to remedy this defect by having the standard made of baked mahogany, as being a substance little effected by change of temperature: or, if composed of metal, to have it constructed on the principle of the gridiron pendulum, an explanation of which the reader will find in the author's Natural Philosophy.

LATITUDE AND LONGITUDE.

The subjects of Latitude and Longitude, strictly belong to Mathematical Geography, and we shall therefore explain the nature, and uses of these subjects, and describe the methods of finding them.

LATITUDE.

The Latitude of a place is its distance in degrees and minutes from the equator, either north or south. When the place is north of the equator it is in *north* latitude; when south of the equator it is in *south* latitude.

Manner of reckoning Latitude.—Latitude is reckoned by *degrees*, *minutes*, and *seconds*. Every circle, great or small, contains 360 degrees; each degree contains 60 minutes, and each minute 60 seconds: so that each minute is the 60th part of a degree, and each second the 60th part of a minute by measure.

These several divisions, for the sake of conciseness are distinguished by signs: thus 30 degrees is written 30°; 15 minutes is written 15′; and 25 seconds 25″.

The length, or magnitude of these several divisions of course depend on the circumference of the circle of which they are parts. The length of a degree on the great circle of the earth, we have already seen is about 69¼ miles.

As latitude begins at the equator and terminates at the poles, it includes a quadrant, or quarter of a circle in each direction; it cannot therefore exceed 90°.

LONGITUDE.

Longitude is reckoned from east to west, or from west to east, and is the distance, in degrees and minutes, from any given place or meridian.

The stations, or meridians from which Longitude is reckoned, are various, different nations having fixed upon some important point, or place of their own for this purpose. Thus the English reckon their Longitude from the Royal Observatory at Greenwich; the French reckon from Paris; the Americans from Washington, &c.

What is the latitude of a place? What are the two kinds of latitude? In what manner is latitude reckoned? What are the signs of degrees, minutes, and seconds? What is the length of a degree of latitude? How many degrees of latitude are there? How is longitude reckoned? From what place is longitude usually reckoned?

It has been usual for geographers and other writers, therefore, to state from what meridians their longitude begins. Most writers, however, of the present day, reckon from Greenwich; and we believe most navigators do the same.

Manner of reckoning Longitude.—As Longitude includes one half of the earth in the same direction, its number of degrees is twice those of Latitude, or 180.

When a place is situated west of the meridian from which Longitude is computed, it is said to be in *west* Longitude:—when east, it is said to be in *east* Longitude.

The length of a degree of Longitude at the equator, is the same as a degree of Latitude; but from this point, owing to the spherical form of the earth, these lines diminish in length, both north, and south, becoming less, and less, as they approach the poles, where they are reduced to nothing.

Uses of Latitude and Longitude.—The uses of Latitude and Longitude are of the highest importance to Geography and Navigation. The relative distances of places, and their positions on maps, charts, and globes, are known by the directions and distances of these parallel lines.

In navigation these are subjects of still higher importance, since without Latitude and Longitude, the mariner would be unable to find his way through the pathless ocean from port to port, and would always be liable to fall upon rocks, and quicksands.

METHODS OF FINDING LATITUDE.

The principles on which Latitude is ascertained by any of the methods known, depend on the supposition that the earth is a spherical body, revolving on its axis, and that it is situated in the centre of the great vault, or hollow sphere of the heavens.

How many degrees of longitude are there? What is the length of a degree of longitude? What are the uses of latitude and longitude? What are the principles on which latitude is found?

The general principles of finding Latitude may be stated in a few words.

We have already seen that Latitude is the distance of any place in a direct, or meridian line from the equator towards the poles, and that the poels are 90 degrees from the equator. If then we can find the distance of any given place on the earth, from the equator, in degrees and minutes, our Latitude is found.

The method of doing this, is to ascertain the altitude of some celestial body, as the sun, or a star, by means of proper instruments, and by knowing the place of which in the heavens, we are enabled to find our own position on the earth, and thus to ascertain our distance from the equator. For, the change which takes place in the apparent altitude of a star, when we move, from one part of the earth to another, either north, or south, is equal to the variations of Latitude.

Example, by taking the altitude of the Sun.—For example, suppose we take the altitude of the sun at midday, and find that it is 44° above the horizon, then, as there are 90° of Latitude between the equator and the pole, if we subtract 44° the sun's altitude, from 90°, the whole number of degrees, we shall have 46° as the Latitude of the place where the observations were made.

If the sun is in the equinox, and therefore his true place known, this is all that is required; but at other times, it is necessary to allow for the sun's declination, that is, his distance from the equator, either north, or south.

For instance, another observation being taken at a different season from Latitude 46°, and the sun's declination found to be 8° north, then his apparent altitude would be 52° instead of 44°. This therefore (his declination) must be subtracted from his altitude, and the remainder from 90°, when the Latitude will be found 46° as before. If the sun's declination be south of the

How may latitude be found by taking the altitude of the sun? When must the declination of the sun be added to, and when subtracted from, the altitude of the sun?

equator, then its amount must be added to his apparent altitude, it being understood that these calculations are made in north Latitude.

The above method, though not precisely accurate, is that commonly employed at sea, and is sufficiently so for the more common nautical purposes. When the exact Latitude of a place or object is required, other methods are employed, and more generally the celestial object is a star, and not the sun. Sometimes several methods are used for the purpose of testing each other, and thus insuring accuracy.

Other methods of finding Latitude.

The following is a summary of the different methods by which Latitude is found.

First. By the altitudes of those stars called *circumpolar stars*, which in northern Latitudes, never descend below the horizon. These are the stars which circulate around the north pole, and belong to the constellation Ursa Major. They are familiarly known by the name of the *pointers.*

Second. By the greatest, and least, altitudes of the sun above the horizon of the place where the Latitude is required, during the year.

Third. By the observed altitudes, or zenith distance, of a star, or other heavenly body, when on the meridian.

Fourth. By the zenith distances of stars, which pass the meridian, near to the zenith of the place.

Fifth. By various altitudes of a star, observed when it is near to the meridian, and then reduced to the true meridian by computation.

None of these methods can be used at sea except the third, a general description of which has already been given, the sun being employed as the celestial object.

As our limits forbid a detail of all these methods, we will select the fourth, as being the most simple, and easily understood by the student.

What are the other methods of finding latitude ?

Fourth.—By the zenith distances of stars, which pass the meridian, near to the observer's zenith.

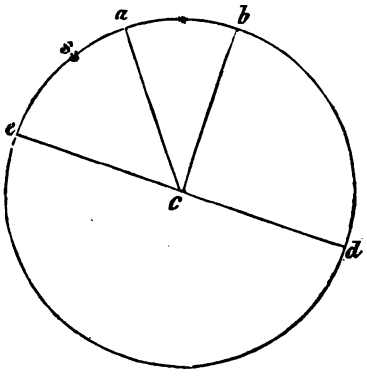
We have already explained the tern zenith. It is 90° from the horizon. Zenith distance is the distance in degrees from the zenith.

When the above method of finding Latitude is employed, the observations are generally made at two places, having different Latitudes, that of one of the places being previously known. It is immaterial whether both places are situated on the same meridian or not; the star must be one that passes near the meridian of both places. The observations are generally made at both places nearly at the same time.

The instrument employed for this purpose is called a *Zenith Sector*, and by which small zenith distances can be measured with great exactness.

For this purpose let *a b*, Fig. 10, be the zenith of any

Fig. 10.



two places; *e d* the equator: and suppose the Latitude of the place whose zenith is *a*, that is *a c*, is known; the object is to find the Latitude of the place of which *b* is the zenith, that is *b c*.

The zenith distance of the star *s*, when it comes on the meridian of both places must be observed.

These observations will give us *a s* and *b s*. If *s* is

to the south of both zeniths, as in the figure, or to the north of both, then the difference between the observed zenith distances will give *a b*: if *s* be to the north of one zenith and south of the other, then *a s* and *b s* together, will give *a b*.

Now *a b* is the difference of the Latitude of the two places, as is evident by the inspection of the figure, and therefore, *a c* being known, we obtain the latitude, that is *b c*, the sum of *a c* and *a b*.

This method was employed in the trigonometrical survey of England, and gave the Latitude with great exactness.

METHODS OF FINDING LONGITUDE.

Before proceeding to point out the means of finding Longitude, it will be necessary to make some explanations with respect to the several methods of computing time, since on its accurate measurement chiefly depends the success of the observer in finding the true Longitude of a place.

It has already been stated under the article 'Solar and Siderial Time,' that there is a difference in the length of a year, when measured by a star, and by the sun.

We are here to explain the difference between what are called *mean*, and *solar* time, and to show what is understood by

EQUATION OF TIME.

Equal and unequal Motions of the Earth.—The diurnal motions of the earth are perfectly uniform, its daily revolutions, as tested by astronomy, having not varied a second from 24 hours in 2000 years.

The fixed stars, by which this equal motion is ascertained, have no motion of their own, but the earth's orbit, or the apparent path of the sun, is elliptical, and hence the earth moves round the sun, not in a perfect circle, but in an ellipse, so that, being attracted by the sun with great-

What is said of the uniformity of the diurnal motions of the earth?

er force in one portion of the orbit, than in another, the earth in its annual revolution, moves faster at one season of the year than at another.

Hence it follows, that the apparent motions of the sun, by which solar time is measured, are irregular, and the intervals of time, which, in the course of the year elapse between the sun's successively leaving, and returning to the same meridian, are of unequal lengths.

An *apparent* solar day, or a day measured by the sun, could not, therefore, be adopted as the standard measure of time, as in the course of the year, the sun is sometimes too fast, and sometimes too slow, when tested by a clock which keeps true time, and it is essential that a standard measure should be an invariable portion of time.

Mean Time.—From the above described irreguality arose the invention of an *artificial* solar reckoning, called *mean solar time*, which is the *average* length of all the apparent solar days in the year and the difference between a mean solar year and an apparent solar year, is called the *Equation of Time.*

When time is computed with reference to the apparent solar day, it is called *apparent* time; when with reference to a mean solar day, it is *mean* time. A sun-dial, or a meridian line, shows the hour of apparent time; and chronometers or true clocks indicate mean time.

Periods when Mean and Solar Time are alike.

The mean day, is of the same length throughout the year, being the 365th part of the earth's annual revolution, or a day and a night, making twenty-four hours.

At four times in the year, mean, and solar time coincide, or the sun and true clock agree. These days are the 15th of April; the 1st of September; the 15th of June, and the 24th of December.

What causes the irregularity of time when measured by the sun? What is meant by mean time? What is equation of time? What is apparent time? What is the length of a mean day? How often does the sun and clock agree?

On the above days, and on no other in the year, is the sun exactly on the meridian of any place at the moment when a true clock indicates the hour of 12. On all other days, mean, and apparent time disagree, the greatest difference between them being 16½ minutes, which happens on the first of November.

SIMPLEST METHOD OF FINDING LONGITUDE.

Having made the above explanations with respect to time, we are now prepared to understand the method by which longitude is determined.

Hourly Motion of the Sun.—The sun in a solar day, or when it returns to the same meridian which it left the day before, may be said, in that time, to have described 360 degrees of longitude, having performed the entire circle of the sphere. Now the solar day being 24 hours, and the number of degrees in the circle 360, by dividing the degrees by the number of hours, we obtain 15, which therefore is the number of degrees through which the sun passes during each and every hour.

Therefore, if we find the sun on the meridian of one place, for instance on that of Greenwich, or if it is 12 o'clock apparent time there, the sun will one hour after, be 15° apparent time to the west of that place:—in two hours, it will be 30° west of that place; in six hours 90°; and in twelve hours 180° west of that meridian.

In other terms, in one hour after it is 12 o'clock at Greenwich, it will be 12 o'clock at any place situated 15° to the west of Greenwich: in two hours, it will be 12 o'clock at a place situated 30° west of Greenwich, and in six, and twelve hours, it will be 12 o'clock at places situated severally at 90° and 180° west of Greenwich.

At Greenwich, the corresponding hours of course will be 1 o'clock in the afternoon, 2 o'clock, 6 o'clock, and 12 o'clock at midnight.

How many degrees of longitude does the sun describe in 24 hours? How many degrees does the sun travel through in an hour? How long after it is noon at Greenwich, will it be noon 15 degrees west?

East and West Longitude.—Beyond 180° of *west* longitude, *east* longitude begins. The only difference in the two cases is, that places situated to the west of Greenwich, are said to have their noon later, and their reckoned time earlier; while those to the east have their noon earlier, and their reckoned time later, than at Greenwich.

How Longitude is found.—Now as the sun travels at the rate of 15° per hour from east to west, if we can by any means ascertain precisely when it is noon at the place where we are, how long since it was noon, at another place east of us, the longitude of which we know, then the longitude of the place where we are is found by simply calculating the degrees and minutes at the rate of 15° per hour.

The use of Chronometers.—Suppose, then, that two chronometers, going at the same rate, are made to indicate 12 o'clock at the meridian of Greenwich, and that one of them remains there, while the other is taken to sea. Then to ascertain his longitude, the Captain at sea, by an observation of the sun, finds when it is 12 o'clock at the place where he is, and by his chronometer, he knows when it is 12 o'clock at Greenwich, and consequently what the difference is between the meridian time of the two places, and thus by a very simple calculation, he learns his longitudinal situation.

Example.—Supsose the Captain sails with his chronometer for America, and after being a time at sea, finds, when it is 12 o'clock by the sun at the place where he is, that it is 3 o'clock at Greenwich by his chronometer (for his chronometer keeps Greenwich time), then he knows, because it is noon where he is, later than at Greenwich, that he is in west longitude, and because he finds that there is three hours difference between his actual time, and the time of Greenwich, he knows that

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Where does east longitude begin? What is the principle on which longitude is found? How does the Captain at sea find his longitude by means of his chronometer?

his place is three times 15 degrees west of that place, and therefore that his longitude is $15 \times 3 = 45°$.

If it is 12 o'clock at the place of observation sooner than at Greenwich, then the observer knows that his longitude is east, and his place is found in the same manner.

Corrections with respect to Time.—But as these observations are made according to apparent time, and without equation, it becomes necessary for the mariner to correct his longitude thus made, by knowing whether his time is too fast, or too slow, that is, whether the sun is behind or before the clock, and accordingly by making additions to, or subtractions from his longitude, to find his true place.

Now what is true of mean time, and the difference of time at one place, and one time, is so at all places, and all at times, and therefore the tables constructed at Greenwich, showing these differences, answer at all times, and in every part of the earth. Thus by knowing on any day of the year, the mean time at Greenwich, as shown by the Nautical Almanac, and also the corresponding mean time at other places, the longitude of such places will be found by converting the difference of time, into degrees, and minutes, as already shown.

Other Methods of finding Longitude.

Although the most simple, and easy method of finding longitude is that already described, still the mere circumstance, that the best chronometers are liable to error, and may, from unknown causes, fail to indicate, even nearly, the true time, especially during long voyages, makes it hazardous to depend on them alone, in a matter of so much importance. Ships with their hundreds of men and millions of property, might be sacrificed in consequence of a small error in the reckoning of longitude.

Other methods have therefore been sought, less liable to error, but the difficulty still remains in a great de-

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Why is it necessary to correct the time in order to find the true longitude? Why are other methods, besides the use of the chronometer, sought to find longitude?

gree, since these methods cannot be employed with facility at sea, where, consequently, chronometers are still almost invariably employed.

The other methods by which longitude is found depend upon certain phenomena exhibited from time to time among the celestial bodies.

First. The eclipses of the moon.

Second. The eclipses of Jupiter's satellites.

Third. The occultations, or concealments, of the fixed stars, by the passage of the moon over them.

Fourth. Eclipses of the sun.

Fifth. The passage of the moon over the meridian of the places, the longitude of which is required.

Sixth. The passage of the moon, compared with that of one or more of the fixed stars, immediately following or preceding the moon, and having nearly the same declination.

Seventh. The distance of the moon from certain fixed stars, or from the sun.

Besides these, there is a method of limited application, by means of explosions of gunpowder made at a place the longitude of which is known, and seen at another, the longitude of which is required.

All these Methods involve the same principles.—These several methods may be considered as founded on a similar principle, and which is the same as that already detailed, namely, to ascertain the relative difference of absolute time at two distant places.

Example, by the Eclipses of Jupiter's Moons.—Suppose, instead of a chronometer there could be some method devised, by which the mariner at sea, should be informed at what moment it was 12 o'clock at Greenwich, and could at the same instant ascertain that it was 4 o'clock, or 4 hours afternoon, at his position, then h s longitude would be 4 hours multiplied by 15°, or 60 , west. On the contrary, if the signal of 12 o'clock

It is said that all the methods of finding longitude are founded on a similar principle: what is that principle?

at Greenwich took place at 8 o'clock in the morning, the Captain would know that his longitude was 60°, east.

Now suppose a celestial phenomenon which could be seen in different parts of the earth, such as an eclipse of one of Jupiter's moons, was calculated to happen at the meridian of Greenwich at 12 o'clock on a given night, and the same eclipse was observed to take place at the same moment, when viewed from a different station, east, or west, then the difference of time by the clock, when the eclipse happened at the two places, when converted into degrees, would give the difference of longitude.

Example, by the flashing of Gunpowder.—The same principle is involved in the method of finding longitude by the flashing of gunpowder. Let two meridians be first ascertained at places east and west of each other, and let two chronometers be regulated by these two meridians. Then at precisely 12 o'clock at night by one of the chronometers, let a keg of powder be exploded, the light of which is seen at the same instant at the other station, and at which let the exact time be noted by the chronometer at that station: then the difference of time between the two chronometers, being regulated by the two meridians, will show the difference of longitude.

By this method, it is obvious that the different longitudes of places, only at comparatively short distances from each other, can be ascertained; and the meridian of one of them from Greenwich mus tbe known, in order to give the actual longitude of the other.

Accuracy of this Method.—This method is considered the most accurate that has been employed for ascertaining the distances of places from each other on the land, and is that recently used in France for the purpose of finding the longitudes of the two extremities of a parallel of latitude.

How may longitude be found by the eclipses of Jupiter's moons? Explain the method of finding longitude by flashing gunpowder.

PART SECOND.

PHYSICAL GEOGRAPHY.

Physical, or Natural Geography, has for its objects, a description of the principal features of the earth's surface, and its natural phenomena: also a knowledge of the several climates, temperatures, and productions of its various parts, and how they are affected by different causes.

Subjects of Physical Geography.—The subjects embraced by Physical Geography, are exceedingly numerous, and many of them highly important to man. Besides a general description of the earth, and its grand divisions into Land and Water, and also its smaller natural divisions, by mountains, seas, bays, and rivers, the details of of our subject will include an account of the changes which the earth has undergone; of the strata composing its crust; of the geological features of its surface; of the vicissitudes of climates, and their causes; of the animals peculiar to each country, and of those common to many; of the plants, and the latitudes in which they grow; of the temperature of different countries, and the lines of equal heat, without reference to latitude; of the atmosphere and its phenomena; of the different quantities of rain which fall in various countries; an account of the fossil bones of different countries: These, and a great

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What are the objects of Physical or Natural Geography? What are the subjects embraced in Physical Geography?

variety of other subjects connected with the physical history of the earth, will fall under our notice, in the course of this volume.

OF THE LAND.

General View.—The total surface of the globe is usually estimated at about 200,000,000 of English square miles. Of this surface, about seven tenths are occupied by the oceans, the other three tenths consisting of land, lying above the level of the water.

The terrestrial surface is divided by oceans into two vast portions of land, called the *Old* and *New*, or the *Eastern* and *Western Continents.*

It is a circumstance deserving notice, that while the general direction of the land in the two continents is entirely different, the direction of the principal *peninsulas*, or *promontories*, in both are quite similar.

The land of the eastern continent extends from south-west to north-east, while that of the western continent runs nearly north and south.

In both, the peninsulas, or parts extending far into the sea, run towards the south, and almost uniformly terminate in a high rocky promontory, having a bay on the west, and an island, or cluster of islands on the east side.

Thus, Cape Comorin has the Arabian Gulf on the west, and the island of Ceylon on the east. Africa terminates in the Cape of Good Hope, and has on the west the Gulf of Guinea, and on the east the island of Madagascar.

The western coast of South America from the straits of Magellan to the tropic of Capricorn, forms one great basin, and on the east are the Falkland and Sandwich islands.

New Holland, which in point of extent may be re-

What is the estimated size of the globe in square miles? What are the proportions of sea and land on the globe? What is the first, or grand division of land? What are the directions of the land in the eastern and western continents? What is said of the direction in which peninsulas of the two continents extend? What capes and promontories are mentioned which extend towards the south?

garded a third continent, on the south-west has a gulf, and on the east the island of New Zealand.

Other instances of projections of land into the sea towards the south, are found in Florida, Greenland, Sweden, Spain, Italy, Corea, Kamtschatka, and Norway.

Extent of the Continents.—The greatest length of the eastern continent in a direct line is about 9000 miles, viz. from the Cape of Good Hope to the north-east part of Siberia. The greatest length of the western continent is from Behrings straits to the river La Plata in South America, about 7000 miles.

OF THE SEA.

General View.—The following are the principal divisions of the great ocean, which surrounds the globe.

This great ocean naturally admits of two grand divisions, viz. The Southern, and Pacific Oceans, the waters of which cover nearly one half of the globe; and the great Atlantic basin, which divides the eastern and western continents.

First.—*The Great Southern and Pacific Oceans.*

This is divided into—

1. *The Antarctic Ocean*, which is comprised between the antarctic circle and the south pole.

2. *The Southern Ocean*, the boundaries of which in one direction are the antarctic circle; on the other, a line drawn from Cape Horn to the Cape of Good Hope; thence to Van Dieman's Land, and then by the south of New Zealand to Cape Horn again. These two divisions are often called, the *Great Southern Ocean.*

3. *The Indian Ocean*, lying between Africa on the west, and the peninsula of Malaya, with the islands of

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What are the lengths of the two continents? What are the two grand divisions of the waters of the globe? What are the divisions of the great Southern and Pacific Oceans? What are the boundaries of the Southern Ocean? What are the boundaries of the Indian Ocean?

Sumatra, Java, and New Holland on the east, and bounded by Persia and Hindostan on the north. The Red Sea, the Arabian Gulf, the Persian Gulf, and the Bay of Bengal, are parts of this ocean.

4. *The Pacific Ocean*, divided by the equator into *north*, and *south*, is bounded by America on the east, and New Holland, and the islands of Java and Sumatra, and the continent of Asia on the west. Behrings straits, and the seas of China and Japan, form parts of this ocean.

These four oceans thus artificially divided for the sake of geographical description, form one vast expanse of water, which extends about 11,000 miles from east to west, and 10,000 from north to south, thus covering nearly one half of the whole earth.

Second.—*The Great Atlantic basin*, forming that expanse of water, which divides the New from the Old world. This includes—

1. *The Atlantic Ocean*, commencing in the south from a line drawn from Cape Horn, to the Cape of Good Hope, and extending north to the arctic circle.

It is divided into the *north* and *south* Atlantic Oceans, by the equator; and its branches form the Mediterranean Sea, the North Sea, the German Ocean, the Baltic Sea, Baffin's Bay, the Gulf of Mexico, Hudson's Bay, and the Caribbean Sea.

2. *The Arctic Ocean*, which surrounds the north pole. It is bounded by the arctic circle, and the northern shores of the eastern and western continents.

These oceans are about 3500 miles in breadth, and 9000 in length.

We have seen that the land amounts to only about three tenths of the whole superficies of the globe, while seven tenths are covered with water.

What are the boundaries of the Pacific ocean? How large are the great Southern and Pacific oceans? How is the Atlantic ocean bounded? What seas are formed by branches of the Atlantic ocean? Where is the Arctic ocean, and how is it bounded?

Quantity of Land and Water in the two Hemispheres. The quantity of land and water in the two hemispheres is very unequally divided, the southern hemisphere being nearly one uninterrupted ocean, beyond the promontory of South America, while the northern, towards the poles, contains more land than water.

The arithmetical proportions of land in the two hemispheres, are equal to about 16 in the northern and 5 in the southern. In other words, if the land in the northern hemisphere be represented by 16, that in the southern would be represented by 5. The quantity of land, therefore, in the northern hemisphere, is more than three times that in the southern.

DEFINITIONS WITH RESPECT TO THE SEA.

A *Sea* is a considerable branch of the ocean, nearly surrounded by the land, as the Baltic, and Mediterranean.

An *Archipelago* is an arm of the ocean, or a sea, containing many islands, as the Grecian Archipelago.

A *Strait* is a narrow passage, connecting two larger portions of water, as the Straits of Gibraltar and Magellan.

A *Channel*, is a wider passage than a strait, as the British channel.

A *Sound*, is a narrow passage of water, or a strait which may be sounded, or its depth found by the lead and line, as Long Island sound.

A *Gulf*, is an arm of the Sea, extending inland, with a wide entrance, as the Gulf of St. Lawrence.

A *Bay*, is an arm of the Sea, stretching inland, and where vessels may ride with safety. A small bay is called a *harbor*.

What proportions of land do the two hemispheres contain with respect to each other? What is a Sea? What is an Archipelago? What is a Strait? What is a Channel? What is a Sound? What is a Gulf? What is a Bay?

Rivers, are large streams of water, composed of many smaller ones, which arise from mountains or highlands, and flow towards the sea, or lakes into which they are discharged.

The courses of rivers are often very circuitous, sometimes running two or three times the distance of their heads from the ocean in a straight line.

DEFINITIONS WITH RESPECT TO THE LAND.

Mountains, are the most elevated portions of the earth. They differ greatly in respect to height; and while some are single, or stand alone, as Vesuvius and Etna, most of them are in extended ranges or *chains*, as the Alps and Andes.

Volcanoes, are mountains which send forth fire from their summits, as Jorullo, and Hecla. Those which bear the marks of fire, but have long been inactive are called *extinct volcanoes*, as those of Auvergne, in France.

Highlands, are elevated, and often extensive portions of land, not rising into mountains, as the Highlands of Scotland.

Plains, are extensive portions of land, with a level surface, or which is not diversified with hills and dales. Elevated plains are called *table lands*, as in many parts of South America.

A *Desert*, is an extensive plain, containing neither vegetation, nor running streams.

A *Vale*, or *Valley*, is a district, watered by streams, and bounded by hills, or mountains. Switzerland contains a great number of valleys.

A *Precipice*, is the steep side of a mountain, or hill. A precipice is called *mural*, when it is nearly perpendicular.

What are mountains? What are volcanoes? What are highlands? What are plains? What is a desert? What is a vale, or valley? What is a precipice?

PHYSICAL DIVISIONS OF THE EARTH BY MOUNTAINS.

In numerous instances the Kingdoms and States which are inhabited by different nations and languages are separated from each other by ranges of mountains, which form natural barriers between them.

Thus the chain of the *Alps* divides Italy from Germany, France, and Switzerland. Its length is about 700 miles.

The *Himmaleh* chain divides Hindostan from Thibet. A ramification of the same range separates Persia from India, and China from Tartary. Its length is about 1500 miles.

The *Uralian* mountains form the barrier between Europe and Asia. Their length is nearly 1000 miles.

The chain of the *Pyrennes* separates France from Spain. Length 200 miles.

The Norwegian chain of mountains divides Sweden from Norway.

These are sufficient for examples of such physical divisions, but many other instances might be adduced, where not only kingdoms, and nations but small states, are thus separated.

In order to obtain a connected view of the most extensive system of mountains on the globe, we will suppose an observer placed in New Holland, with his face towards the north. America will then be on his right hand, and Asia and Africa on his left.

Suppose then, his vision were sufficient for the purpose, he would see from Cape Horn to Behrings Strait, along the western coast of America, an almost uninterrupted range of the highest mountains. From Behrings Straits proceeds another vast chain, passing in a south

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What is said of the divisions of kingdoms and states by mountains? What mountain separates Hindostan from Thibet? What countries do the Alps divide? What chain separates Spain and France? What nations are divided by the Uralian chain?

westerly direction through Asia, leaving China and Hindostan on the south, and though somewhat interrupted as it approaches Africa, may still be considered as continuing its course in the mountains of Persia, and Arabia Felix. From Cape Gardafui in Africa, to the Cape of Good Hope, the chain is continued, which completes the view.

This series of mountains, is in the form of an immense irregular curve, which comprises within it, the Pacific and Indian Oceans, with innumerable islands, besides a portion of Asia, including China, the Burman Empire, and the Indian peninsula. It presents a steep face towards these oceans, while on the other side, the land generally slopes away towards the Atlantic and Arctic Oceans.

HEIGHTS OF MOUNTAINS.

The following is a table of the heights of some of the principal mountains on the globe, reckoning from the level of the sea. The elevations of those of Asia and Africa, are far from having been ascertained with any considerable degree of accuracy. The heights are however given according to the most recent admeasurements. In the table, *h* denotes the highest point in the range to which it belongs, and *v*, volcanoes.

EUROPE.

		Feet.
Mont Blanc *h* . .	.	15,668
Mont Rosa . .	.	15,527
Ortler Spitze in the Tyrol	.	15,430
Aiguille d'Argenture .	.	13,389
Eiger . . .	.	13,170
Jungfrauhorn . .	The Alps	13,730
Shreckhorn . .	.	13,310
Wetterhorn . .	.	12,500
Pass of Great St. Bernard	.	7,968
Ditto of Mont Cenis	.	6,778
Ditto of the Simplon	.	6,580

		Feet.
Nethou *h* . .	Pyrenees .	11,427
Perdu . . .	Pyrenees	11,275
Canigou . . .	Pyrenees .	9,145
Monte Corno *h* (Apennines)	.	9,523
Lomnitz *h* (Carpathian)	. .	7,962
Sneehaetta *h* (Dovrefield in Norway)		8,122
Mulhacen *h* (Sierra Nevada of Granada in Spain)	. . . .	11,678
Mont Mezin *h* (Cevennes in the south-east of France)	. . .	6,567
Puy de Sancy *h* (Mountains of Auvergne in France)	. .	6,215
Etna *v* in Sicily	. . . .	10,870
Vesuvius *v* near Naples	. .	3,932

ASIA.

Dhawalagiri	Himalaya . .	28,077
Jewahir	Himalaya . .	25,747
Mowna Roa (Sandwich Islands)	.	15,988
Ophir (Sumatra)	. . .	13,840
Egmont (New Zealand)	. .	11,430
Italitzkoi (Altaian chain)	. .	10,735
Ararat (Armenia)	. . .	9,600
Olympus (Anatolia)	. . .	6,500
Awatsha *v* (Kamtschatka)	. .	9,600
Lebanon (Palestine)	. . .	9,600

AFRICA.

Geesh	Abyssinia	15,000
Amid Amid	Abyssinia . .	13,000
Lamalmon	Abyssinia	11,200
Chain of Atlas *h*	. . . . .	11,980
Peak of Teneriffe *v*	. . . .	12,180

AMERICA.

Chimborazo *h* . .	Andes .	21,425
Cayambe . . .	Andes	19,633
Antisana *v* . . .	Andes	19,136
Cotopaxi *v* . . .	Andes .	18,867

		Feet.
Yliniza . . .	Andes	17,376
Tolima . . .	Andes	18,324
Cotocache . . .	Andes	16,436
Pichincha *v* . . .	Andes	15,931
Farm of Antisana (inhabited)	Andes	13,437
City of Quito . .	Andes	9,542
Popocatepetl *v* . . .	Mexico	17,720
Iztaccihuatl	Mexico	15,705
Coffer of Perote	Mexico	13,275
Lake of Toluca . . .	Mexico	12,195
Silla de Caraccas (Venezuela)		8,633
Duida (Mountains of Parime)		8,314
Itacolumi (Brazil) . . .		5,756
Mount Washington *h* (Alleghanies)		6,650
Blue Mountains (Jamaica) . .		7,278
Mount St. Elias		17,863
Mount Fairweather . . .		14,736

Mountains of less elevation not included in the above list.

	Feet.
Mount Ida (Turkey) . . .	5,000
Mount Hecla (Iceland) . . .	6,000
Moose Hillock (N. Hampshire) .	4,500
Ben Nevis (Scotland) . . .	4,300
Saddle Mountain (Mass.) . .	4,000
Round Top Catskill range (N. York)	3,800
Cairngorum (Scotland) . .	4,000
Table Mountains (S. Carolina) .	4,000
Snowdon (Wales) . . .	3,500
Ascutney (Vermont) . . .	3,300
Rock of Gibralter (Spain) . .	1,500
Mount Tom (Mass.) . . .	1,500
Mount Holyoke (Mass.) . .	1,250

GENERAL VIEW OF THE FORMATION AND STRUCTURE OF THE EARTH.

Our knowledge of the interior of the earth, with an exception or two, extends only to a few hundred yards

below the surface; and even to this depth, our knowledge is confined chiefly to mining districts, where shafts have been sunk in search of coal, salt or the metals. Our general information therefore, with regard to the internal formation of the earth is exceedingly limited, and is chiefly obtained by the digging of wells and canals, and the appearance of the banks of rivers, and other steep decrivities.

From the facts derived from these sources, however, and their general agreement with each other, we are warranted in the conclusion that the crust of the earth, generally, is not composed of masses of materials thrown together in confusion, but that considerable, and often the nicest order has been employed in their arrangement. In many places, where the original positions of the materials have been obviously changed by some upheaving force, we may still observe the marks of pristine order, among the fragments thus dislocated.

Stratification.—If we drain a lake or pond, and then examine its bottom, by a slight excavation, we shall find it composed of layers of materials placed one above the other in regular order. These layers are called *strata*, and such formations are said to be *stratified*.

It is evident, from the appearance of such formations, whether they are found at the present day, under water or not, that the materials composing their strata must have been deposited from a fluid, this being the only possible mode of accounting for their stratification.

Now a great proportion of the crust of the earth, at inconsiderable depths from the surface, are found lying in strata like beds of peat, and although at the present time, they may be elevated far above the level of the sea, and at hundreds of miles from any standing water, we still must infer that they have been deposited from water, and therefore that the water must have been drained off, or that the land has been raised above its surface by some subterranean force.

Why is it necessary to believe that the materials composing stratified rocks were deposited from water?

Most of the Earth was once covered with water.—As a great proportion of the materials of which the crust of the earth is composed are stratified, so we must conclude, that most of the earth was once covered with water, and as in many instances these strata amount to hundreds, lying one above the other, we must infer that the water covered such districts for a great length of time, but for what periods we have no means of determining.

When therefore we observe a stratified rock lying with its strata inclined ever so much to a horizontal line, and at any height above the level of the sea, we have no other reasonable mode of accounting for the fact, than to believe that it was formed in horizontal strata under water, and that some power from beneath has elevated the rock from its original place, and in doing so, has given the strata the inclination, and the rock the position in which we find it.

Had the water escaped, and left the strata undisturbed, they would still have retained their original horizontal position as represented by Fig. 11. From the very nature of the case, this must have been so, since making no allowance for the inequalities of the bottom; a fluid can never deposite its sediment in curved, or inclined lines. But allowing for such inequalities at the commencement of the deposition, still the upper strata would become horizontal, since the deepest portions would first be filled by the rolling down of the coarser materials.

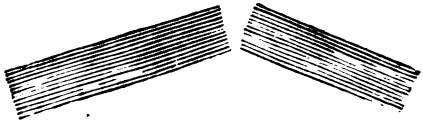
Fig. 11.

Broken Strata.—No imaginable form of the bottom, could indeed account for the appearance of strata in various parts of the world, as they actually exist, since there is the most indubitable evidence from the phenomena they exhibit, of their having been disturbed, dislocated, or actually broken asunder as represented by

Why is it supposed that a great proportion of the earth was once under water? Had the water escaped, and left the strata undisturbed, in what position would it have remained without further disturbance?

Fig. 12, and which appearance can only be reconciled with the supposition of an enormous force acting from

Fig. 12.



below, and pushing the strata upwards, by which the fracture was produced.

We then arrive at the conclusion, with as much certainty as the strongest circumstantial evidence will admit, that the crust of the earth has been disturbed, upheaved, and broken, by a subterranean force acting with inconceivable power, and as we cannot imagine any other agent adequate to produce such mighty effects except that of volcanic fire, so we must conclude that this was the agent employed.

In this manner must we account for the changes which have evidently taken place in the positions of the solid strata of the earth, since their first formation.

Kinds of rock which have undergone this change.—The principal rocks which have most evidently undergone great changes by a subterranean force, are *Mica-slate, Clay-slate, Sandstone, and Limestone.*

In making deep excavations into the earth for mining purposes, the different strata at various places have been observed to the depth of twelve, or fourteen hundred feet, and it is often the case that they amount to several hundreds. These it must not be understood are all of different materials, the same kinds being repeated, several times in forming the whole.

Thus in a coal mine in England, the beds or strata passed through, to which the miners give different names amount to sixty-five in number, the same being repeat-

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By what train of reasoning is it concluded that the strata have been disturbed by volcanic forces? What rocks are mentioned as having undergone great changes? What is said of the number of strata discovered in coal mines?

ed so as to form an almost innumerable number in the whole. The following is an example of the manner in which these strata, or beds succeed each other. Clay-slate, Limestone, Clay-slate, Coal, Clay-slate, Coal, Gravel, Clay-slate, Gravel, &c.

CLASSIFICATION OF ROCKS.

It is obvious that since the earth consists of many rocks, differing materially from each other, in appearance and composition, they must be designated by different names for the purpose of description, otherwise, writers on Geology and Physical Geography, would not be able to understand each other; and for the same reason, books for general instruction, must point out these differences in order to be understood.

For the purposes of this treatise, it will be sufficient to divide rocks into *Primary*, *Secondary*, *Tertiary*, and *Volcanic*.

PRIMARY ROCKS.

Primary, or primitive rocks, are those which are supposed to have been first formed, and from the disintegration, or breaking down of which, the others have proceeded. These are *Granite*, *Gneiss*, *Mica-slate*, *Primitive Limestone*, *Porphyry*, and some others.

These rocks are all destitute of organic remains, or the remains of animals of any kind, and hence are supposed to have been formed before the creation of living existences.

So far as location is concerned, the primitive rocks appear to have remained where they were originally placed, though some of them bear the marks of disturbance by subterranean forces, their strata being dislocated and broken, and sometimes made to incline nearly in a perpendicular direction.

Some of the primary rocks are stratified, while

Why is it necessary that rocks should be classified and named? What are the names of the several divisions of rocks? What are the primary rocks? Why are they called primary?

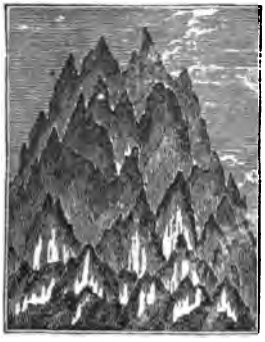
others, show no marks of strata, being crystalline in their structure, with no appearance of successive layers.

Granite.—This rock is composed of three distinct minerals, *Quartz*, *Felspar*, and *Mica*, closely compacted together, forming an individual rock.

These several component parts are in the form of irregular crystals often of considerable size, and generally easily distinguished from each other in the same specimen.

Granite forms the lowest and most substantial portion of the earth's crust, and for aught we know, reaches hundreds of miles in depth or below the surface. It also forms most of the high mountains of the globe, often rising in the form of rugged points or peaks, far above any surrounding surface, as represented by fig. 13.

Fig. 13.



These rocks appear never to have been moved from the places in which they were originally formed, differing in this respect, as well as in their obvious crystalline structure, from all the rocks, of which the earth is composed.

The color of granite depends on those of the several minerals which compose it. Generally it is light gray, passing into dark gray, on the one hand, and into nearly white on the other.

Gneiss.—This rock may be considered a stratified granite. It is composed of the same materials as the former rock, disposed in stripes, or imperfect layers, in the direction of which it may be split, while granite, is

What are the materials composing granite? Are these materials distinct to the eye, or not? What is said of the height and depth to which granite reaches? What is the color of granite? What is the composition and structure of gneiss?

no more fissile in one direction, than in another. Its grains are generally finer than those of granite.

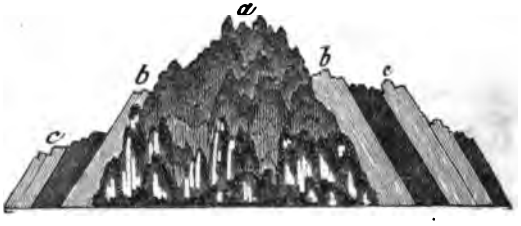
Where granite and gneiss occur together, which is almost invariably the case, the latter is superincumbent on the former, or rests with various degrees of inclination on its sides.

Mica-slate.—This rock is composed chiefly of quartz and mica, the felspar being, in most instances, wanting. The materials are commonly in fine grains, and the rock eminently stratified, and fissile in its structure, the layers being readily separated in thin slabs, often of many feet in length. These are employed to a considerable extent in this country, as flagging stones for the sidewalks of cities.

Granite, Mica-slate, and Gneiss commonly occur in the same districts, and often in the same mountain.

Gneiss, by insensible gradations, passes into granite on the one hand, and into mica-slate on the other, and as the three occur together, the gneiss lying between the others, instances are not uncommon, where within the thickness of a foot or two, the three denominations of rocks all occur together, the under portion being granite, the upper mica-slate, with the gneiss between them.

Fig. 14.



These positions are illustrated in fig. 14, where *a* is the granite, *b b*, the gneiss, and *c c* the mica-slate.

When granite and gneiss are together, how are they situated with respect to each other? What is mica-slate composed of? How does granite differ from gneiss? How does gneiss differ from mica-slate? What is said of the passage of one of those rocks into the other?

There is no probability that these stratified rocks were formed in the often nearly perpendicular positions in which they are now found, but that the inclination of their strata has been caused by the elevation of the granite by subterranean fires.

SECONDARY ROCKS.

The *Secondary Rocks* are next above the primary, and on which they rest. These rocks have obviously proceeded from the disintegration, or falling in pieces of the primitives, large masses of which they always contain.

It is probable that the secondaries were formed at that period of the world when the primary rocks were forced up from the bottom of the ocean, and when the dislocations and disruptions of the original strata were produced, which are every where so apparent at the present day.

That these mighty changes took place after the creation of living creatures, is proved by the fact that the remains of animals of the lowest orders are sometimes found embedded in secondary formation.

The rocks belonging to the secondary formation, are *Sandstone*, *Secondary Limestone*, *Chalk*, *Secondary Porphyry*, and some others.

TERTIARY FORMATION.

The *Tertiary*, or third formation, was deposited subsequently, of course, to the secondary, on which it rests. It is therefore a more recent production, and may be forming at the present day.

The tertiary strata proceeded from the destruction and degradation of the primary and secondary rocks. These strata consist of beds of *Clay*, *Sand*, *Marl*, and the *newer Limestone*, the different species often obvious-

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What is the situation of the secondary rocks with respect to the primary? How were secondary rocks formed? What rocks belong to the secondary formation? From whence did the tertiary formations proceed? What does this formation consist of?

ly depending on the species of rock in the vicinity, from the destruction of which they are produced.

The sea coast of the several Southern States in America, consists of tertiary strata.

VOLCANIC ROCKS.

By *Volcanic Rocks*, are meant those which owe their origin to volcanic fire. These are *Trap*, *Greenstone*, *Basalt*, and the different kinds of *Lava*, which are found in the vicinity of burning mountains.

Some of these are among the most recent productions, being formed wherever a volcano pours forth its liquid contents; while others were formed before the historical era, and under circumstances which no longer exist, the causes which formed them, having ceased with their production.

Trap, *Greenstone*, and *Basalt*, though no longer in the course of formation, were produced in a comparatively recent age, since they are all found resting on, and above the secondary strata.

These rocks are neither stratified, nor crystaline, in their structure, but are fine grained, and compact, often containing fragments of other minerals embedded in them.

The igneous origin of these rocks is proved by the fact often observed, that when they come into contact with other rocks, the effects of heat on the original strata are always apparent.

The most common, and undoubtedly the true theory of the production of the trap rocks, is that they were forced up from beneath the crust of the earth, in a melted state.

THE ATMOSPHERE.

Many of the phenomena which a physical history of the earth presents, and which we shall have occasion

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What are volcanic rocks? What are the names of the volcanic rocks? How is it supposed that trap rocks were produced?

to describe, cannot be understood without reference to the Atmosphere, with which the earth is surrounded, and to which, therefore, the attention of the pupil will now be called.

General View of the Atmosphere.—The atmosphere, or the "sphere of vapors," is that invisible, elastic fluid which every where surrounds the earth, and reaches to an unknown height above it.

On this elastic fluid, every living creature is, at each moment dependent for its existence; and every plant for its growth; for no seed will vegetate without the presence of oxygen, one of the components of the atmosphere. Without it there would be neither rain, dew, nor wind, nor would these be of the least use, since no organized beings would exist.

The Atmosphere is the grand agent which tempers the climates of the different zones, conveying heat, and cold to the several regions, so as to make all inhabitable to man.

Composition.—The Atmosphere is composed nearly of 80 parts of nitrogen, and 20 of oxygen to the 100.

It also contains a small portion of carbonic acid gas.

Extent of the Atmosphere.—The superficial extent of the Atmosphere at its lower surface, or where it rests upon the earth, is 200,000,000 of square miles, this being the superficial contents of the earth's surface.

Its Height as a uniform elastic fluid, considering it of the same density throughout, as at the earth's surface, and calculating its pressure at 15lbs. to the square inch, would be about five and a half miles. But being an elastic fluid, its pressure and density are greatest at the surface of the earth, and therefore both diminish in a ratio proportionate to its height.

What is said of the necessity and uses of the atmosphere? How does the atmosphere temper the heat and cold of climates? What is the composition of the atmosphere? What is the superficial extent of the atmosphere? What would be the height of the atmosphere, measured by its pressure, were its density uniform?

The actual height of the Atmosphere, or the size of its volume, is a problem which never has been solved.

In consequence of the repulsive property of its particles, its rarity increases in proportion as its own pressure diminishes, but to what extent it swells by this expansive force, we have no means of determining.

It is proved by the twilight, that is, by the light which continues after the setting of the sun, that the Atmosphere is sufficiently dense to contain vapors which reflect the light at the height of 45 miles from the earth.

Weight of the Atmosphere.—The weight of the Atmosphere at the level of the sea is equal to 15 pounds to every square inch of surface, and as there are 144 square inches in a square foot, each square foot of surface sustains a pressure equal to 2160 pounds.

This pressure is equal to that of a column of mercury 30 inches high, or to that of a column of water 34 feet high. The pressure of the atmosphere, on the whole surface of the earth, is calculated to be equal to the weight of a globe of lead, 60 miles in diameter.

The pressure of the atmosphere is called *barometrical* pressure, because its degrees are measured by the barometer.

Principle of measuring altitudes with the Barometer.

As the mercury in the barometer tube is retained in its place by the pressure of the atmosphere, and as this pressure at the level of the sea is equal to about 30 inches in height of the mercury, it is plain that if this tube of mercury be elevated above the level of the sea, the mercury would fall below the 30 inches in proportion to the diminution of the pressure. It is on this principle that the heights of mountains are determined by the barometer.

Construction of the Barometer.—The Barometer is

What is known of the actual weight of the atmosphere? How high does the twilight prove the atmosphere to be? What is the weight of the atmosphere? What is the principle on which the heights of mountains are measured by the barometer?

an instrument of very simple construction, consisting of a glass tube *d* fig. 15, filled with quicksilver, and a cistern *b* of wood, or ivory, also containing quicksilver, and into which the lower end of the tube is immersed. The upper end of the tube only is closed, the mercury playing freely from the cistern into the lower end, and from the tube into the cistern. The bottom of the cistern is closed by means of a piece of leather, which serves at once to confine the mercury, and at the same time allow the pressure of the atmosphere to act on it.

Fig. 15.

The screw *v*, having on its upper end a small disc, is designed to act on the mercury through the leather bottom, and to throw up the whole column, so as to fill the upper part of the tube, that the glass may not be broken by the motion of the metal in carrying.

Between *d* and *e* is a graduated scale into inches and tenths of inches; but by means of a graduated slide, called a *vernier*, these tenths are again divided into ten parts, thus dividing the inches into hundredths.

This description is designed for the common, or stationary barometer. In that form of the instrument called the *Mountain* barometer, the scale is increased in length, so as to measure the descent of the mercury when it is carried to the top of a high mountain.

The variations of the height of the barometer, which stands at the same place, must of course depend on the variations of the density of the atmosphere at that place. In this respect there is a considerable difference in different countries. In London this amounts to 3 inches, from 28 to 31. In some parts of this country, where records have been kept, it amounts to 1½ inches.

How is the barometer constructed? How does the common differ from the mountain barometer? What does the variation of the height of the barometer at the same place depend on? Are these variations the same in different countries, or not?

In the polar regions, according to Capt. Parry, the highest range was 30.86.

Near the equator, or between the tropics, the variations of the mercury are very small, amounting, it is said, to only the 67th of an inch.

Mean altitude of the Barometer in England.—The barometrical records of the Royal Society of Great Britain are published annually, and the mean altitude for each year given. From these tables, it appears that the mean height for a series of years is 29.89.

The mean height in each year for 14 years is as follows:

Years.	Height.	Years.	Height.	Years.	Height.
1787,	29.80	1792,	29.87	1797,	29.92
1788,	29.96	1793,	29.93	1798,	29.92
1789,	29,79	1794,	29.91	1799,	29.84
1790,	29.98	1795,	29.90	1800,	29.90
1791,	29.87	1796,	29.89		

Now, although the variations of the barometer in England, as already stated, amount in the course of the year, to about 3 inches, still the average difference between any two years is exceedingly small, the greatest difference for fourteen years, as shown by the above table, being only 18 hundredths of an inch, viz. from 29.80 to 29 98.

Changes of weather indicated by the Barometer.

The altitude of the mercury in the barometer, as we have already seen, is subject to considerable variations, which must depend on the greater or less pressure of the atmosphere; and numerous observations in various parts of the world have been made with a view of ascertaining whether these barometrical changes indicated, with any certainty, corresponding changes in the weather.

What is said of the variations of the barometer, between the tropics? What was the difference in the mean altitude of the barmometer in England in the course of 14 years?

From these observations, the following rules, or facts, have been deduced, and which in their turn, have been confirmed by very general experience during a long series of years.

First. In calm weather before rain, the mercury is commonly low.

Second. In serene, good settled weather, the mercury is high.

Third. Preceding and during great winds, without rain, the mercury sinks very low.

Fourth. In calm, frosty weather, the mercury stands high.

Fifth. The mercury is highest during long continued, clear, cold weather, in the winter.

Sixth. After a storm attended with wind when the mercury is low, it rises very rapidly when the sky becomes clear.

Seventh. When the sky is overcast and lowering, the mercury sinks, though no rain follows.

Whoever will watch the variations of the barometer, for a series of years, as the writer has done, will confirm the truth of these rules.

That the density of the atmosphere should be diminished before, and at the time of rain, is what might be supposed to take place without reference to the barometer; for, such a state, it is nearly obvious, must take place, in order that the water it contains may be deposited.

If the density of the medium in which the moisture floats continues specifically greater than the moisture itself, then according to the laws of Hydrostatics, the moisture would never be deposited, and we should have no rain. And that this is the case during dry weather, is indicated by the barometer, for then the mercury always stands high.

The above observations with respect to the changes

In what weather is the barometer low, and in what weather is it high? Why ought we to expect a fall of the mercury before it rains? If the air continues specifically heavier than the moisture it contains, what weather will follow?

of the weather which the barometer indicates are condensed and affixed to the scale of the common instrument for the purpose of showing at a single glance, what the weather is to be. Thus—

Inches.	Words annexed.
31.	Very dry. Hard frost.
30.50	Settled fair. Frosty.
30.	Fair. Frost.
29.50	Change.
29.	Rain. Snow.
28.50	Much rain. Much snow.
28.	Stormy.

Thus during dry frosty weather, the barometer ranges highest, though in this country, or rather in New England, its altitude is never equal to 31 inches. When the mercury is sinking, we may expect falling weather, and when it begins to rise, we may most certainly expect to see the sky in a few hours.

TEMPERATURE OF THE ATMOSPHERE.

We have seen above, that at the level of the sea, the atmosphere is most dense during the coldest weather, or in other terms, that in general, the barometer ranges highest, when the thermometer is lowest.

In ascending from the level of the sea, however, the indications of these two instruments are coincident, the thermometer falling in proportion as the density of the atmosphere diminishes.

It has been found that an elevation of 300 feet from the level of the country at the equator, diminishes the temperature one degree, as indicated by the thermometer. This arises not only from the increased rarity of the air, but also from the diminution of reflected heat from surrounding objects.

After ascending the first 300 feet, the increased alti-

When and where does the barometer range highest when the thermometer is lowest? In what proportion does the temperature sink as we ascend from the earth?

tude necessary to sink the thermometer another degree, diminishes to 295 feet. From this point it falls another degree, at 277 feet, and another at 252 feet, and so on in these proportions, so that at 1539 feet of elevation, the thermometer will fall six degrees. The usual calculation however, is 300 feet of elevation, to one degree of diminished temperature at the equator.

According to this calculation, allowing the temperature at the equator to be 80 degrees, the temperature of 32 degrees would be found at the altitude of 14,400 feet, because there are 48 degrees between 32 and 80; therefore if the thermometer sinks one degree to 300 feet, then 48 multiplied by 300, will give the altitude at which the thermometer will sink to 32 degrees, which is 14,400.

Altitude of perpetual congelation greatest at the equator, and least at the poles.—It is obvious, that other circumstances being equal, the temperature at a given height must depend on the distance north, or south of the equator. For, since the diminution of heat, as we ascend, depends much on the diminished reflection from the earth, owing to distance only, this reflection must depend on the temperature of the earth over which the ascent is supposed to be made. Thus the altitude of perpetual congelation would be greatest at the equator, and least at the poles.

Accordingly, it is found that the elevation, where there is perpetual frost, depends, in a degree, but not entirely, on the latitude, as shown by the following table.

Suppose the temperature at the earth is 80°, at what altitude will it be 32°, allowing one degree to 300 feet ascent? On what does the diminished tempera ure of different elevations from the earth depend?

Table of the altitudes of perpetual congelation in different latitudes.

Latitude.	Height in feet.	Latitude.	Height in feet.
0°	15,000	45°	7,671
5	15,095	50	6,334
10	14,761	55	5,034
15	14,220	60	3,818
20	13,478	65	2,722
25	12,557	70	1,778
30	11,484	75	1,016
35	10,287	80	457
40	9,001	85	117

It will be observed that these estimates do not coincide exactly with the degrees of latitude, which ought to be the case were they founded on theory alone. We may therefore take this table as the result of actual experiment, and suppose that the want of a ratio of coincidence between the degrees of latitude and those of temperature, depend upon the local situations over which the experiments were made. Thus it is plain that the point of congelation over the sea, and over an elevated plain would not be equal, since the reflection of heat from both surfaces would not be the same.

THERMOMETERS.

The instrument by which the temperatures of places are determined is the *Thermometer*, or heat measurer. One form of this instrument, that of Fahrenheit, being quite common, and almost universally employed in this country, needs no description. Nor shall we here explain the principle on which the Thermometer is founded, this also being sufficiently common and familiar to most readers. But it being an important subject in Physical Geography to determine the comparative temperature of different countries, it becomes necessary for

What is the general difference between the heights of perpetual congelation from the equator to the poles?

this purpose, for the pupil to understand the difference between the several Thermometers employed in foreign countries, and in our own.

Three several Thermometers, with as many different scales are employed by scientific writers. By the German authors that of Römer (*Reaumur*) is employed. The French use that invented by Celsius, a Swedish philosopher, and called the *Centigrade* Thermometer. In Great Britain and America, and indeed, wherever the English language is spoken, the graduation of Fahrenheit is preferred.

No doubt these different scales have often been a source of error in estimating, and comparing the temperatures of different countries.

In order therefore to enable the student in Physical Geography to compare the three scales, we here insert a diagram, Fig. 16, containing them all, so, that their differences, and relation to each other may be seen at a glance.

In addition to these, there is another scale still employed in Russia, viz. De Lisle's; but as Russian authors are rarely quoted in matters of science, we only give its manner of gradation.

Graduation of different Thermometers.

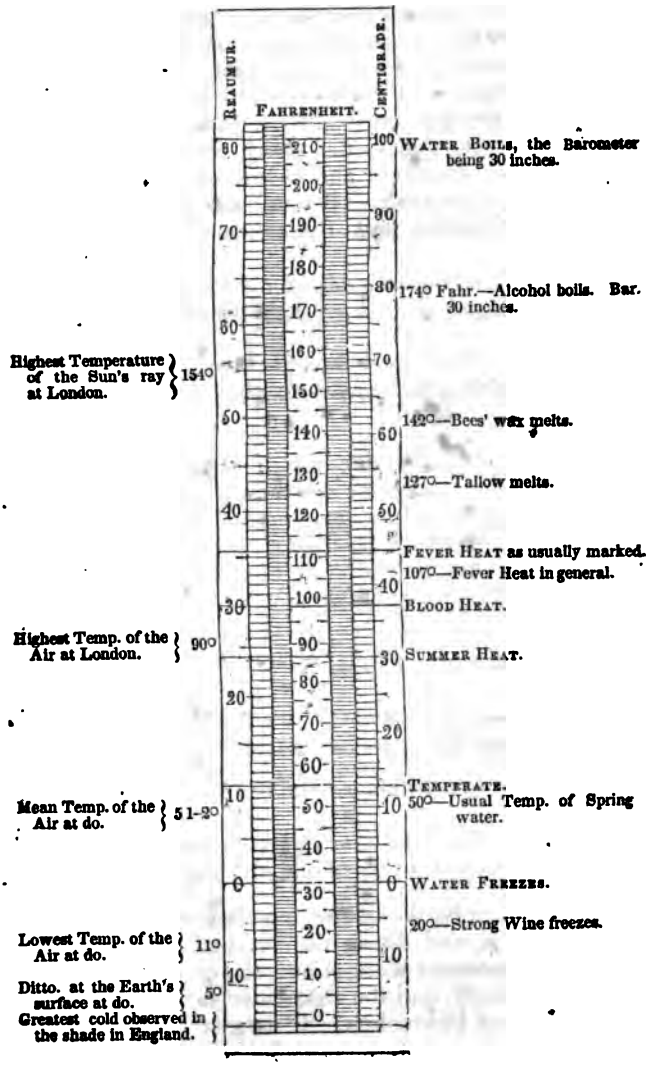
The two important points, that of freezing, and that of boiling water, are thus stated on the above mentioned scales.

	Fahrenheit.	Centigrade.	Reaumur.	De Lisle.
Boiling point,	212°	100°	80°	0°
Freezing point,	32	0	0	150

The number of degrees contained between the boiling and freezing points, is therefore in Fahrenheit 180, Centigrade 100, Reaumur 80, De Lisle 150. It follows then, that 9° Fahr. is equal to 5° Centig. 4° Reaum. and 7½° De Lisle. Fahrenheit's is therefore the smallest de-

What are the three thermometers generally employed? What is the freezing point on the scale of Fahrenheit? What are those of Celsius and Reaumur? What are the number of degrees between the boiling and freezing points in each of these scales?

Fig. 16.


Reaumur.
Fahrenheit.
Centigrade.
Water Boils, the Barometer being 30 inches.
174° Fahr.—Alcohol boils. Bar. 30 inches.
Highest Temperature of the Sun's ray at London. 154°
142°—Bees' wax melts.
127°—Tallow melts.
Fever Heat as usually marked.
107°—Fever Heat in general.
Blood Heat.
Highest Temp. of the Air at London. 90°
Summer Heat.
Temperate.
Mean Temp. of the Air at do. 51-2°
50°—Usual Temp. of Spring water.
Water Freezes.
20°—Strong Wine freezes.
Lowest Temp. of the Air at do. 11°
Ditto. at the Earth's surface at do. 5°
Greatest cold observed in the shade in England.

gree with respect of space, and Reaumur's the largest. The sign 0° is called *Zero*, which in the scale of Fahr. is 32° below the freezing point, while in those of Cen. and Reaum. it is at the freezing point.

All the degrees on each scale below zero, are called *minus*, and are distinguished by a dash before the number of degrees, thus —15°, which signifies 15° below zero. In the Reaumur and Centigrade scales, the degrees above zero are called *plus*, and are marked thus +15°, to distinguish them from minus.

Rules for changing any one of the three Scales into the equivalent degrees of the other.

To change Fahrenheit into Reaumur.—The proportions of these two scales are to each other as 9° Fahr. to 4° Reaum.

Rule.—Multiply the number of degrees of Fahrenheit, when this is more, or less than 32 by 4, and divide the product by 9, and the quotient will be the equivalent number of degrees on Reaumur's scale. If the given number on Fahrenheit is more than 32, the degrees on Reaumur will be *plus;* if less *minus.*

Examples.

Fah.	Reau.			
41°	=+4°,	for 41−32= 9	9×4=36	36÷=+4°
14°	=−8°,	for 32−14=18	18×4=72	72÷=−8°

See these corresponding numbers on the scale.

To convert Reaumur into Fahrenheit.—Each degree of Reaumur is equal to $2\frac{1}{9}$ of one of Fahrenheit.

Rule.—Multiply the given number of degrees of Reaumur by 9, and divide the product by 4. If the degrees of Reaumur were *minus*, the quotient must be deducted from 32, and the remainder will be the equivalent degrees of Fahrenheit. If the given degrees were not *minus* the quotient must be added to 32°, and the sum will be the equivalent sought.

Examples.

Reau. Fah.

$-12^\circ = 5^\circ$, for $12 \times 9 = 108$. $108 \div 4 = 27$. $32 - 27 = 5^\circ$

$+16^\circ = 68^\circ$, for $16 \times 9 = 144$. $144 \div 4 = 36$. $36 + 32 = 68^\circ$

Fahrenheit into Centigrade.—Each degree of Fahrenheit is equal to $\frac{5}{9}$ of one of Centigrade.

Rule.—Multiply the number of degrees of Fahrenheit, when the number is more, or less than 32, by 5, and divide the product by 9; the quotient will be the equivalent number on the Centigrade scale. If the number of Fahrenheit be more than 32, the Centigrade degrees will be *plus*; if less *minus*.

Examples.

Fah. Cent.

$50^\circ = +10^\circ$, for $50 - 32 = 18$. $18 \times 5 = 90$. $90 \div 9 = 10^\circ$

$23^\circ = -5^\circ$, for $32 - 23 = 9$. $9 \times 5 = 45$. $45 \div 9 = 5^\circ$

Centigrade into Fahrenheit.—Each degree of the Centigrade is equal to $1\frac{4}{5}$ of Fahrenheit.

Rule.—Multiply the given number of degrees of the Centrigrade by 9, and divide the product by 5. If the Centigrade were *minus*, the quotient must be deducted from 32, and the remainder will be the equivalent degrees of Fahrenheit. If the given degrees were not *minus* the quotient must be added to 32, and the sum will be the equivalent sought.

Examples.

Cent. Fah.

$-15^\circ = 5^\circ$, for $15 \times 9 = 135$. $135 \div 5 = 27$. $32 - 27 = 5^\circ$

$+10^\circ = 50^\circ$, for $10 \times 9 = 90$. $90 \div 5 = 18$. $18 + 32 = 50^\circ$

Reaumur into Centigrade.—Each degree of Reaumur is equal to $1\frac{1}{4}$ of the Centigrade.

Explain the rules by which a degree of one thermometer is reduced to the equivalent of another.

Rule.—Multiply the given number of degrees by 5, and divide the product by 4, and the quotient will be the equivalent number on the Centigrade.

Example.

Reau. Cent.
16°=20°, for 16×5=80. 80÷4=20°

Centigrade into Reaumur.—Each degree of the Centigrade is equal to $\frac{4}{5}$ Reaumur.

Rule.—Multiply the given number of degrees of the Centigrade by 4, and divide the product by 5, and the quotient will be the equivalent number on Reaumur's scale.

Example.

Cent. Reau.
60°=48°, for 60×4=240. 240÷5=48°.

American Almanac for 1832.

ON ISOTHERMAL LINES.

It is found by experiment, that some places at equal distances from the equator, or in the same degree of latitude, are warmer, or colder than others. This difference depends on local causes, as vicinity to the sea, prevailing winds, altitude, insulation, &c.

A line passing through the several places having the same temperature, without respect to latitude is called an Isothermal line. This term is derived from the Greek *isos* and *thermos*, and signifies *equal heat.*

A treatise on this subject published several years ago, by the celebrated traveller and philosopher, Humboldt, gives many curious and instructive results.

It had long been known on comparing the climates of Europe and America, that temperature did not depend on the direct heat of the sun alone. But it remained

What are meant by isothermal lines? Mention the latitudes through which the several isothermal lines pass, in Europe and America?

for M. Humboldt to show the degrees of difference, and also to explain the subject in a much more clear and philosophical manner than had been done before. The following are the results of some of his observations.

Latitudes of Isothermal lines passing through Europe and America, the degrees of heat, being the mean annual temperature.

The Isothermal line which indicates the temperature of 32 degrees, or the freezing point of water, passes through Ulea in Lapland, Lat. 66°, and Table Bay in North America, Lat. 54°.

The Isothermal line of 41 degrees runs near Stockholm in Sweden, Lat. 59½°, and through St. George's Bay in Newfoundland, Lat. 48°.

The line of 50 degrees runs through the Netherlands, Lat. 51°, and near Boston, Mass. Lat. 42½°. It is the boundary of the wine grape.

The line of 59 degrees runs between Rome and Florence, Lat. 43°, and near Raleigh in North Carolina, Lat. 36°. This line is nearly the boundary of the olive and fig.

Taking similar latitudes, the following table shows the difference of temperature between the west of Europe, and the east of North America. The table shows the mean annual temperature of both regions, corresponding to the same degrees of latitude.

Latitude.	West of Europe.	East of America.	Difference.
30°	70° 1′	66° 8′	3° 3′
40	63 1	51 5	8 6
50	50 8	37 9	12 9
60	40 0	24 0	16 0

The Isothermal lines, as well as the above table, prove beyond all doubt that Eastern America, under the same degrees of latitude, is much colder than Western Europe, and that this difference increases in proportion to the

What is the result respecting the comparative temperatures of Europe and America?

distance from the equator towards the pole. In latitude 30° this difference is only 3° 3′, while in latitude 60°, it amounts to 16°.

Causes of these different Temperatures.—In attempting to account for this difference in the temperature of Europe and America, we must advert to the situation of the two countries with respect to the sea, and to the land with which they are connected. North America is connected with the polar circle by large tracts of land, some of which are from three to five thousand feet in height, and towards the north, always covered with snow or ice.

Europe, on the contrary, is separated from the polar circle by the Northern Atlantic, and Arctic Oceans.

Mean Temperature of the Sea.—The ocean has every where a tendency to preserve a mean temperature, which it communicates to the contiguous land, so that it tempers the climate, moderating alike the heat, and cold.

For this reason the climates of islands, and of seacoasts, are essentially different from those of the interior of continents, the more maratime climates being characterised by mild winters and temperate summers.

Europe has an insular climate.—The whole of Europe, when compared with the eastern parts of America has an insular climate. America, on the contrary, is connected with the polar regions by an uninterrupted line of continent, which, on an average of the whole distance, is, for at least six months in the year, covered with snow. The northwest winds, therefore, which prevail during the winter, and which pass over one continued sheet of snow from the north pole, are a great source of cold to all the northern regions of America, their cooling effects reaching as far south as the fortieth, or even the thirty-eighth degree of latitude.

These northern blasts, so piercing in all the north

Explain the reason why Eastern America is colder than Western Europe?

eastern parts of the United States, do not reach Europe without passing a wide ocean; the temperature of whose waters being always considerably above the freezing point, serve to elevate and soften their temperature before they reach the land.

The difference of climate and temperature in the two countries, is therefore explained, at least in some degree, by their respective situations with reference to sea and land, together with the height of the latter.

Influence of Mountains on climates.—It is well known that mountains have a great influence on the temperature and climate of a country.

In proceeding from the equator towards the pole, on the level of the sea, we must advance a considerable distance before reducing the mean annual temperature a single degree. But by increasing our elevation, a rapid change of temperature will be experienced, for we have only to gain an altitude of about three miles, when we arrive, even at the line of the equator, to the region of perpetual frost, as already stated.

The cold of the upper regions, as already explained, seems to depend on the increased expansion of the air, and on the diminution of heat reflected from the surface of the earth.

The diminution of heat, as we leave the equator on the level of the sea, depends chiefly on the decreased influence of the solar rays, and is exceedingly gradual, when compared with the change which takes place by an increased elevation.

Table showing the Temperature of different Latitudes.—The following table shows the mean temperature at the level of the sea, from the equator to the 90th degree of north latitude, which when compared with the table formerly given, of the height of perpetual congelation, will show the difference.

On what does the cold of the upper regions depend? On what does the diminution of heat at the level of the sea depend? What difference is there between the temperature of the equator, and that of 10 degrees from it?

Latitude.	Temperature.	
0°	84°	2′
10	82	6
20	78	1
30	71	1
40	62	5
50	53	6
60	45	0
70	38	1
80	33	6
90	32	0

Thus on a level of the sea we must travel the distance of 4000 miles, or equal to one sixth of the earth's circumference, to diminish the temperature to the same degree, that an elevation from the equator, of less than three miles will do.

Influence of Mountains on Temperature.—In the application of these principles in accounting for the actual effects of high mountains on the temperature, and climate of a country, it must be remembered that cold air is specifically heavier than hot; and therefore, that a mountain rising to the height of perpetual congelation, having its summit constantly covered with ice, will, as constantly send down a stream of cool air to its base, at all such seasons as the air is warmer there, than at the summit. Hence it is, that mountains temper the climate of a country, and render many regions salubrious, and inhabitable, which otherwise would have been desolate.

The equatorial regions of South America are illustrations of the effects of mountains on climate.

There vegetation gains its utmost exuberance, and man enjoys a climate unequalled in salubrity and comfort; while the plains of Africa, under the same degrees of latitude, are almost deserts in vegetation, and

How far must we travel from the equator to find a temperature equal to that of three miles above it? How is the difference between the climates of South America and Africa, in the same latitudes, accounted for?

are inhabited only, by such animals as can live in a temperature, which is insupportable to all others.

Influence of the Sea on Climate.—The effects of the sea on the temperature of places have only been noticed incidentally, in accounting for the difference in the climates of Europe and America. This subject deserves further attention.

It is shown by the above table, how very gradually the temperature diminishes in receding from the equator towards the poles, provided the observations be made on a level with the sea. But, independently of distance from the equator, the water itself has a tendency to preserve an equal temperature, every where, and throughout the year.

Oceans of great depth, are not heated in the summer, nor cooled in the winter, so as to become of the same temperature as the contiguous atmosphere, or the adjoining land. The highest temperature of sea-water, in the hottest parts of the earth, is never above 86 or 87 degrees, while on land, the heat of the air sometimes rises to 160 or even 180 degrees.

On the contrary, the sea, except in the highest latitudes, is never cooled down to the freezing point.

Climate of St. Helena.—Perhaps one of the most instructive and satisfactory instances of the effect of the sea in equalizing temperature, is found at St. Helena.

This Island is situated within 16° of the equator, and is more than 1000 miles distant from any other land, being in comparison, a mere speck on the vast expanse of the Southern Atlantic. It is therefore a fair illustration of our subject.

Notwithstanding the tropical situation of this Island, its climate is one of the most pleasant and salubrious any where to be found. During some seasons the thermometer in the hottest month does not rise higher than

What is said of the general effect of the ocean in equalizing temperature? What is the highest temperature of sea-water? What is the latitude of St. Helena? What is the climate of St. Helena?

72° in the interior of the island. At Longwood, the late residence of Napoleon, the thermometer during the year commonly ranges between 56° and 68°, thus making only 12° difference between the heat of winter and summer, an amount of difference which in our climate often takes place in a few hours.

Climate of London and Quebec.—It is from the same influence that we may account for the difference of climate and temperature which exists at London and Quebec. The latitude of London is 51° 31′; that of Quebec 46° 49′; so that the latter is situated nearly 5 degrees north of the former: and yet the mean annual temperature of London is 51° 8′, while that of Quebec is 41° 7′, the annual difference being more than 10 degrees.

At Quebec, the ground is generally covered with snow from November till April, while in London snow seldom covers the ground more than a day or two at a time.

Influence of Currents on Temperature.—The influence of the currents of the ocean, and the drifting of icebergs, must not be overlooked in attempting to account for the annual temperature of places, and the unequal division of heat in different seasons.

Gulf Stream.—Among such currents the Gulf Stream is the most important, both with respect to its extent and influence.

This current, it is well known, issues from the Gulf of Mexico, through the Bahama Channel, at the rate of four or five miles an hour, and flows to the north-east, opposite the whole coast of North America, turning gradually to the east until it reaches the banks of Newfoundland.

From Newfoundland it turns to the south, and passes near the Azores, and finally, with its rapidity constantly

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What difference is there in the temperature of summer and winter at St. Helena? How is this equal temperature accounted for? What are the latitudes of Quebec and London? Which is the coldest place, London or Quebec? How is this difference explained? Whence does the Gulf Stream issue?

diminishing, reaches the north of Europe, on the coasts of Scotland and Norway.

According to Major Rennell, during the summer, the temperature of the Mexican Gulf is about 86°, which is at least 7° above the temperature of the Atlantic Ocean at the same season and in the same latitude.

This stream reaches the Azores in about 78 days, having flown in a circuitous line nearly 3000 miles. Thence it extends its course towards the Bay of Biscay in lat. 48° still retaining an excess of temperature of about 5° above the mean temperature of the sea, through which it passes.

This vast stream of warm water tends to moderate the climate of every northern country along which it passes. The north and west of Europe, in an especial manner, feels its influence in the winter season.

Sheet of Warm Water in the Atlantic.—Another immense sheet of warm water is described by Rennell, in his work on Currents, as existing in the North Atlantic, between the parallels of 33° and 35° north latitude, and which he calls the 'recipient of the Gulf Stream.'

This water is covered with a sea weed, called *sargasso*, more generally known under the name of Gulf weed, and which the current floats in abundance from the Gulf of Mexico.

This mass of water is nearly stagnant, and is warmer by 7° or sometimes 10° than that by which it is surrounded. It appears to float over the surface of the Atlantic, in the same manner that a fresh water river overflows that of the sea into which it runs.

Major Rennell estimates the extent of this 'recipient,' together with the surface occupied by the current from the Gulf, as covering about 2000 miles of the North Atlantic, in the direction of east and west, and 350 from north to south, which is a larger area than that of the whole Mediterranean sea.

What is the direction of the Gulf Stream? What is its temperature? How long is the Gulf Stream in reaching the Azores, and what is the length of its course to that point? Where is the recipient of the Gulf Stream, and what is the area which it covers? What is the temperature of this vast sheet of water?

The heat of this vast body of tepid water is constantly maintained by fresh supplies coming from the south by means of the Gulf Stream.

There is no doubt, but the general climate of some parts of Europe and America, are materially affected by this great reservoir of warmth in the northern ocean.

Influence of Icebergs.—While contiguity to the ocean, and especially the influence of the Gulf Stream, tend to diminish the cold of climates, there is an erratic cause, in floating fields of ice, which, on some coasts, tends to a contrary effect. What are termed *Icebergs*, are masses of ice which have been detached from the frozen regions of the north, or south pole, and floated away by the waters of the ocean.

Sometimes vast numbers of these ice islands, are seen in the midst of the widest oceans, standing at various heights above the surface, and exhibiting to the mariner, at once, a splendid, and fearful spectacle.

Icebergs have often been seen, the summits of which were 200 feet above the surface of the water, which, according to experiments in the arctic seas, would make the depth 1400 feet below the surface; it having been ascertained that only a seventh of the thickness of floating ice stands above the water.

Nor does this appear to be the extent of some of these masses, since Capt. Ross saw several Icebergs aground in Baffin's bay, where he found the water to be 1500 feet deep.

Some of these bergs float as far south as the 40th degree of latitude,where by melting in the summer season, they cool the water sensibly to the distance of forty or fifty miles around them.

Such masses, floating into the vicinity of any coast, would materially affect the summer season, especially in the direction in which the wind carried their chilling

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What is supposed to be the effect of this warm water on the adjoining climates? What are icebergs? What portion of an iceberg is it said rises above the surface of the water? How far south do icebergs sometimes float?

influence. Maj. Rennell states that in the vicinity of one of these islands, the thermometer sunk 18° below the ordinary temperature of the atmosphere.

Navigators inform us, that these Icebergs are sometimes of great extent, and that they occasionally contain large trees standing on them. These trees often have the appearance of being partly burned, which is accounted for, by supposing that the violent friction of the trees against each other, when two bergs happen to meet, sets the wood on fire, which is stated, by eye-witnesses, to have happened.

We are also informed that on these immense floating masses, there are sometimes lakes of fresh water, formed by the melted snow with which their surfaces are often covered.

Polar Currents.—There are two currents of the sea which constantly flow from the polar regions towards the equator, and when they arrive to within about 28 degrees of that line on each side, they change their direction, forming a general movement of the tropical waters towards the west.

The existence of these two polar currents is proved by the movement of masses of ice from the frigid, into the temperate regions.

It is said that the opposition of this polar current from the arctic region, was the chief cause which prevented the success of Capt. Parry in reaching the north pole.

It is equally certain that a tropical current exists, moving from the east towards the west, since floating bodies move in that direction, and vessels crossing the equator are also carried rapidly in the same direction.

The origin of the polar currents is in a great measure to be looked for in the earth's centrifugal force, already fully explained in Part I., and from which it will be recollected, that the effect of the greater motion at the

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What is the effect of these mssaes on the temperature of the neighborhood? What are polar currents? What direction do these currents take near the equator? How is the existence of the polar currents proved? How is the great tropical current proved? What occasions the polar currents?

equator than at the poles, is to produce an accumulation of matter at the former, at the expense of that of the latter.

The same principle explains the effect now in question, the waters moving with increasing velocity from each pole towards the equator, where not immediately partaking of the earth's motion, they are left behind, so that as the earth turns from west to east, the water has, with respect to the land, a motion towards the east, or in the direction contrary to that of the earth's motion.

It is probable also, that the greater evaporation of the water under the tropics by the intense heat of the sun, than at the poles, would occasion a slow but constant movement from the latter towards the former, in order to supply the loss.

This cause, there is reason to believe, co-operates with the centrifugal force to increase the polar currents.

GULF STREAM.

We have already traced the Gulf Stream from the Bahama Channel, through the Atlantic to the northern coasts of Europe, for the purpose of showing its effects on climate.

We have also shown that there is a grand movement of the tropical oceans towards the west, and we are now prepared to understand how this westward movement of the waters gives origin to the Gulf Stream.

Had the land been so situated as to have given no obstruction to the westward motion of the waters above described, the Gulf Stream would never have existed.

It is therefore to the position of the land, that we are to look for an explanation of this phenomenon, and if a map of the world be examined, it will be seen that the great projection of the eastern coast of South America, presents a barrier to this westward motion of the water, and that the position of the coast, from Cape St. Roque, in about 5 degrees of south latitude, extending

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Explain how the tropical current is formed. What is said of evaporation in assisting the polar currents? What two combined causes have produced the Gulf Stream? What part of the American coast turns the great western current of the ocean towards the north-east?

towards the mouth of the river Amazon, is such as to give a portion of the westward current a new direction, and to turn it along the American coast towards the north-east.

This shape of the coast, therefore, together with the general motion of the great mass of waters which surrounds the globe, towards the west, is the cause of the phenomenon in question.

The water, after being turned towards the north-east, runs along the eastern coast of America, and entering the Gulf of Mexico, through the strait formed by the west end of the island of Cuba, follows the windings of the Mexican coast, and passing the Bahama Channel, traverses the whole coast of North America to Newfoundland, by which it is turned towards the east, as formerly described.

CHANGES WHICH HAVE BEEN EFFECTED ON THE EARTH'S SURFACE.

Many facts and circumstances show that great changes have taken place in the surface of the earth. Some of these changes have been effected within the era of history, and are now in progress; while others happened before the creation of man, or other animals. Some of them happened suddenly, while others have been going on ever since the earth was in its present form.

These changes have been the effects of two principal agents, which are opposed to each other in their modes of action and their consequences, namely, *Aqueous* and *Igneous*.

The first includes the action of water, whether running, or in the form of waves of the sea.

The second consists of the action of earthquakes and volcanoes.

Besides the effects of these causes, the fall of mountains, has produced considerable changes on the surface of the earth. These are the effects of sometimes one, and sometimes the other of the above agents.

Describe the course of the Gulf Stream from Cape St. Roque to Newfoundland.

AQUEOUS CAUSES.

Action of Running Water.—The changes produced on the earth's surface, by the long-continued and incessant action of running water, have been very considerable, there being scarcely a section of country, which does not exhibit more or less of its effects.

The effects of running water are of two opposite kinds, namely, that of *Deposition*, and that of *Excavation.*

DEPOSITION FROM WATER.

By *deposition from water*, we mean all such solid matter as is brought down by rivers, and thrown upon their banks, and which accumulates along their channels, or at their mouths.

Depositions from the Nile.—M. Dolomieu, a learned French geologist, has shown the probability that the tongue of land on which the city of Alexandria was built, about 300 years before Christ, did not exist in the days of Homer, 600 years before that period, the ground being formed within that time by the alluvial matter brought down by the Nile, aided by the sand cast up by the sea.

Since that period, and within the era of more certain history with respect to such subjects, it is well established that great changes have been wrought in that vicinity by these causes.

The lake Mœris, which Strabo the geographer describes, about the time of the Christian era, as being of *six leagues* in length, is now by the united action of the Nile and the sea, reduced to almost nothing.

The ancients reckoned eleven mouths of the Nile, of which seven were navigable. At the present day, only two are navigable at all times of the year.

What are the two opposite effects of running water on the earth? What is meant by depositions? What is said of the ancient existence of the land on which Alexandria was built? What change has the lake Mœris undergone since the Christian era?

The cities of Rosetta and Damietta, which were built on two of the ancient mouths, less than a thousand years ago, and which cities then stood on the sea-shore, are now six miles distant from it.

At the same time that the sediment of the Nile is thus extending the land into the sea, the bed of the river itself, and the flat country which it once every year entirely overflowed, are now considerably more elevated than formerly. Ten centuries ago, a rise of the Nile, which covered all the land usually overflown, must now be higher by 3½ feet to irrigate the same lands. According to this statement, the ground must have been elevated by the sediment of the river, at the rate of 4¼ inches in a century, and this elevation is still going on as formerly.

Depositions from the Rhone.—The delta of the Rhone, like that of the Nile, is constantly augmenting. What was a harbor a thousand years since, where vessels anchored, near one of the mouths of this river, is now solid land, six miles from the sea.

Some idea may be formed of the quantity of solid matter which the Rhone brings down, when it is known that a tower erected at its mouth, in 1737, as a landmark to mariners, is already a mile from the shore, the sea having retreated to that distance in a century, in consequence of depositions from its waters.

The quantity of sediment accumulated off the mouth of the Rhone, is such as to form bars by the action of the waters of the Mediterranean, when the wind is from the south.

When this wind continues for a day or two, these bars, composed of fresh water sediment, are covered by marine shells, being thrown there by the waves.

Thus we learn how in some instances, marine shells may be interposed between fresh water strata, a phenomenon which may be accounted for by supposing

What is said of the situation of Damietta and Rosetta? How much higher must the Nile rise at the present day to overflow its banks, than formerly? What is said of the extent of land formed by the sediment of the Rhone?

such places to have been alternately occupied by fresh and salt water.

Stoney deposits from the Rhone.—A great proportion of the more recent depositions from the Rhone, consists, not of incoherent earthy matter, but of *solid rock* of limestone.

The particles thus consolidated, are received by the waters of the Rhone in their passage through limestone countries. In the passage of this river through France, it is known to be fed by many springs containing carbonate of lime, and the fact that its sediment forms a solid mass, is therefore well accounted for.

Sediment from the river Po.—The Po is the principal river of Italy. It rises in Piedmont, and flows north-east to Turin, thence running easterly, it divides Austrian Italy from the states of Parma, Modena, and the Pope's dominions, and finally enters the Mediterranean at the Gulf of Venice, by four mouths. In its course, the Po receives many tributary streams from the Alps, which in consequence of the melting ice of the mountains, are subject to great and sudden inundations. In consequence of the concentration of the waters of these tributaries in its bed, the Po itself annually overflows its banks, and sometimes becomes a sweeping flood, bringing down vast quantities of sedimentary matter.

The solid matter, thus brought down and deposited by this river, in the course of about 1800 years, has accumulated to such an extent that the shore along its mouths has been projected into the sea to the distance of 18 or 20 miles; and along the coast of the Adriatic to the extent of more than 100 miles, the Po, and Adige, with the assistance of several other rivers, have brought down such quantities of matter, as to have increased the land, from two to twenty miles in breadth, the whole distance.

The town of Adria, which was a seaport in the time

What is said of the stoney deposits of the Rhone? How is the formation of this matter accounted for? How extensive is the solid land deposited by the Po, and other rivers along the shores of the Adriatic?

of Augustus, is now twenty miles inland, and Ravenna, which was also a seaport, is now four miles from the shore.

Delta of the Ganges.—This celebrated Asiatic river has its source in the mountains of Thibet, a branch of the Himmaleh, among which it winds in various directions nearly 800 miles. Leaving these mountains, it flows through Hindostan, to the Bay of Bengal, a distance of about 1200 miles. In its course it receives 11 rivers, all of considerable size, and one or two, nearly as large as the Ganges itself.

The head of the delta of the Ganges is 220 miles in a direct line from the sea, at which place the river divides into two principal arms, which, receding from each other in the from of the letter Y, reach the sea at the distance of 200 miles from each other. The whole of this delta was formed by the mud of the river.

The tract thus included within the two branches of the river, according to Major Rennell, is equal in extent to the whole of the principality of Wales.

This immense plain, during the annual flood, is covered with water, forming a gulf which extends inland more than 200 miles, and so great is the quantity of water, and of mud with which it is charged, that the sea at that season becomes turbid at the distance of 60 miles from the coast.

So great has been the quantity of sediment which this river has transported from the lands through which it descends, that besides the delta above described, it has gradually diminished the depth of the water in the Bay of Bengal to the distance of about 100 miles.

Islands formed by the Delta of the Ganges.—The annual flood of the Ganges usually covers the delta to the depth of about 30 feet, and under ordinary circumstances no great changes are made in the soil. But during extraordinary floods vast excavations are sometimes

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What is the distance of Adria, a former sea-port, from the sea? Whence does the river Ganges take its rise? How extensive is the delta of the Ganges? To what extent does the sea become turbid during the flood of the Ganges?

made in a few days, new channels being cut, while the old ones are filled up.

In this manner, new islands are formed in different parts of the delta, being surrounded by new channels which the water has excavated. In the course of a few years, the islands thus marked out become permanent by the deepening of the channels, and the deposition of additional matter on their surfaces. By such means, islands of great extent are formed, which become clothed with the most luxuriant vegetation, forming impenetrable thickets, or jungles, where tigers, buffaloes, deer, and other wild animals take shelter.

After a few years more, these islands are cleared, and become the residence of numerous inhabitants, rivaling in size and fertility, says Rennell, the Isle of Wight.

But they are subject to the most disastrous inundations, for when the periodical flood is at its height, if there happens a wind which sets the tide into the Bay, thus opposing the current of the river, there is danger that the water will rise so as to inundate all such islands.

This actually happened in 1763, when the water rose six feet above the ordinary floods, and the inhabitants of a considerable district, with their cattle and houses, were totally swept away.

We might extend the examples thus given, of the changes produced on the surface of the earth by running water, by similar statements with respect to other rivers, which are subject to inundations, on every part of the globe. But these are sufficient for the intention of this work, as they show that from this single cause, which is commonly overlooked in treating of Physical Geography, that great changes have been made, and are still progressing, in the proportions of sea and land in different parts of the world. It will be seen, however, as we advance, that if the earth makes encroachments upon the sea in one place, the sea makes reprisals in another, and therefore that the relative proportions of the two great surfaces of the globe have suffered little change.

What is said of the islands formed on the delta of the Ganges ?

QUANTITY OF SEDIMENT IN RIVER WATER.

The subject of depositions from running water, ought not to be concluded without noticing the experiments which have been made to determine the quantity of sediment which water is capable of transporting, and which is actually carried into the sea by rivers.

The celebrated hydrographer, Manfredi, concluded from some experiments he had made, that the average proportion of sediment in all the running water on the globe which reached the sea, to be $\frac{1}{175}$ part of the water itself, and imagined from such data, that it would take 1000 years for the sediment thus carried down, to elevate the bottom of the sea one foot.

But the most recent, and probably the most accurate set of experiments which has been made on this subject, are those of the Rev. Mr. Everest, "On the earthy matter brought down by the Ganges."

Mr. Everest found that in 1831, the number of cubic feet of water discharged by the Ganges per second was as follows:

During the rains,	(4 months)	494,208.
During the winter,	(5 months)	71,200.
During the hot season,	(3 months)	36,330.

In round numbers, therefore, we may state that 500,000 cubic feet are discharged per second during the 4 months of the flood season, from June to September, and only 100,000 during the other eight months of the year.

The method of ascertaining the quantity of water discharged, is to measure the breadth and depth of the river at some convenient place, and ascertain its velocity. This is repeated many times during the rise and decline of the flood, and also during the winter, and

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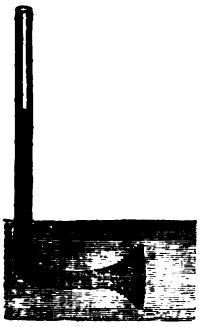
What was Manfredi's estimate of the quantity of sediment carried into the sea? What quantity of water in cubic feet does the Ganges discharge per second during its flood? What is the method of ascertaining the quantity of water discharged?

summer months, so as to determine as nearly as possible, the average quantity during each season.

The velocity may be determined by the instrument, fig. 17, which is a glass tube with a wide open mouth, bent in the manner seen. This is graduated by finding by actual experiment with a floating body, how fast any stream of water runs, and then placing the instrument in the stream, and observing how much above the level, the water is forced into the upright portion of the tube, and marking it accordingly.

Fig. 17.



On making several such experiments on streams flowing at different rates, and marking the different heights to which the water rises, the instrument is prepared for ascertaining without any further trouble the velocity at which any part of the river flows.

Method of finding the quantity of solid matter.—Having obtained the volume of water, we are next to enquire what is the proportion of solid mater it contains.

For this purpose a definite quantity of the water, for example a quart, is taken on different days, sometimes from the middle of the river, and sometimes near the banks, and at different depths, so as to obtain an average quantity of the sediment.

This water is then evaporated, and the solid residuum carefully weighed, and thus the mean quantity of the sediment during the rainy season is found.

The same observations must be repeated for the other portions of the year, and thus the mean quantity for the whole year will be obtained.

By a series of such observations and experiments, Mr. Everest ascertained that the average quantity of solid matter in the water of the Ganges during the flood, was $\frac{1}{4\,1\,3}$ part of the weight of the water.

Now as the water is about one half the specific grav-

What is the method of finding the quantity of solid matter in the water?

ity of the dried mud, the solid matter discharged is equal to the $\frac{1}{856}$ part of the water in bulk, and as the quantity of water discharged is 500,000 cubic feet per second, the 856th part of this, will give the bulk of the solid matter in cubic feet per second, which is nearly 584.

Reckoning the 4 months of the flood at 122 days, the quantity of solid matter carried down during that time was 6,055,727,200 cubic feet. The proportion of sediment during the other seasons was comparatively small, the total amount during the five winter months being only 247,881,600 cubic feet, and during the three months of summer, only 38,154,240 cubic feet. The total annual discharge of solid matter, therefore, was equal to 6,331,763,040 cubic feet.

In order to give some idea of the magnitude of this result, let it be assumed that the specific gravity of the dried mud is equal to one half that of granite, which is not far from the truth, then the quantity of earthy matter brought down in a year would be equal to 3,165,881,520 cubic feet of granite.

Now about 12½ cubic feet of granite weigh one ton, and it is computed that the great Pyramid of Egypt, were it of solid granite, would weigh about 6,000,000 tons. The mass of matter therefore, which the Ganges annually transports into the sea, or deposites on its delta, is, according to this estimate, equal in weight and bulk, to forty-two of the great Pyramid of Egypt.

It is difficult by any comparison, to convey to the mind an adequate conception of the mighty scale on which this vast river transports solid matter from one place to another.

According to the above estimate, the mud which it carries along during its flood is equal to 24 tons of granite every second, and therefore to 1440 tons every minute.

A fleet, it has been calculated, of eighty ships, each

What quantity of solid matter in cubic feet does the Ganges transport to the sea in a year? What quantity of granite in cubic feet is this equal to? How many Pyramids equal to the largest in Egypt, is it said this is equal to? How many tons per second is the transportation of the Ganges equal to? How many ships would carry an equal quantity, at the rate of 1400 tons each?

freighted with 1400 tons of mud, and arriving every hour, day and night, for four months, could not do more than bring from the higher country to the sea a quantity of solid matter equal to that borne down by the Ganges.

EXCAVATIONS AND DESTROYING EFFECTS OF WATER.

Having in the preceding pages given examples of the changes which have been produced by the accumulating effects of water on the shores of the sea, we will next advert to the encroachments of the sea upon the land.

A proportion of the eastern coast of England, has from time immemorial, been wasting away from the destroying action of the water upon the land.

Many towns and villages, marked on ancient maps, no longer exist, their places being now occupied by the sea, or by sand banks.

Coast of Yorkshire.—Nearly the whole coast of Yorkshire, from the mouth of the Tees, to that of the Humber, is in a state of gradual dilapidation.

In the old maps of that shire, we find spots now sand-banks in the sea, where the towns and villages of Auburn, Hartburn, and Hyde were once located.

Of Hyde, says Mr. Pennant, only the tradition is left; and near the village of Hornsea, a street called Hornsea Beck, has long since been swallowed up.

On the river Humber, near the sea-coast, the sites, and even the very names, of places, once towns of note, are now only recorded in history.

Ravensport was at one time a rival of Hull, and a port so very considerable in 1332, that Edward Baliol, and the confederated English Barons, sailed from hence to invade Scotland, and Henry IV., in 1399, made choice of this port to land at, to effect the deposal of Richard II.; yet the whole of this, has long since been devoured by the merciless ocean, and extensive sands, dry at low water, are seen in their places.

What is said of the destroying effects of the sea, on the eastern coast of England? What is said of several ancient places on the river Humber?

Destruction of Dunwich.—Dunwich was once, one of the most considerable seaports on the eastern coast of England, but from the most ancient accounts, the land in its vicinity was subject to encroachments from the sea. According to ancient records, two tracts of land which had been taxed in the town of Dunwich, in the eleventh century, were soon afterwards devoured by the ocean. Subsequently, the losses recorded are, at one time, a monastery; at another, several churches; at another, the old port of the town; afterwards, four hundred houses at once; then the Church of St. Leonards, the high road, the town hall, &c.

In the sixteenth century, it is stated, that at that time, not one quarter of the ancient town was standing.

At the present day, a single Church, the last of twelve mentioned in the ancient records as belonging to Dunwich, is still standing. This city, anciently one of the most flourishing and populous on that coast, has now given place to a little village of the same name, consisting of about twenty houses, and 100 inhabitants.

Isle of Sheppey.—The Isle of Sheppey is situated at the mouth of the Thames, and was once a considerable island, yielding abundance of corn, and feeding vast flocks of sheep. It was fortified by the Romans, and was an important military station. At present it is six miles long by four in breadth.

This island has been wasting away by the undermining of the sea, from the time of the earliest records. The cliffs on the north, which are from sixty to eighty feet high, are rapidly disappearing, fifty acres having been carried away within the last twenty years.

The Church, now near the coast, is said, only fifty years ago, to have been in the middle of the island, and it is conjectured that at the present rate of destruction, the whole island will be covered by the waves in about fifty years more.

Towards the east end of the island stands the Church of Reculver upon a cliff of sand and clay about twenty

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What account is given of the destruction of the town of Dunwich? Where is the Isle of Sheppey situated?

feet high. This was the military station of the Romans, and so late as the time of Henry VIII., about the beginning of the 16th century, the Church stood about one mile from the shore. Sometime before 1780, the waves reached the site of the Roman camp, the walls of which had continued for several years after they were undermined, to overhang the sea, being firmly cemented into one mass. These walls were 80 yards nearer the sea than the Church, and are spoken of as having fallen into the water in 1780. In 1804, the waves had reached the church-yard, which with several houses adjoining were carried away, and at that time the Church was dismantled, and abandoned as a place of public worship, on account of the danger of its falling.

In 1834, however, it was still standing with its two lofty spires, fig. 18, being almost from time immemorial a well known landmark, to the mariners along that

Fig. 18.

What account is given of the destruction of this island by the sea?

coast. It would however long since have fallen, had not the force of the waves been checked by an artificial barrier of stone and wood, raised for its protection.

Goodwin Sands.—A sand bank known by this name lies along the coast of Kent. It is about ten miles long, and from three, to seven miles wide, There is a tradition that the estates of Earl Goodwin, the father of Harold II., who died in 1053, were situated here, and some have conjectured, that they were overwhelmed by the flood mentioned in the Saxon chronicle about 1100. From some examinations made by boring, with reference to the erection of a lighthouse on these sands, it was inferred that they were the remains of ancient land, and not an accumulation of sea sand.

Straits of Dover.—It has often been a conjecture among geologists, that England was once united to France at the point where the two kingdoms are now separated by the Straits of Dover. In 1753 a scientific society at Amiens in France, proposed this subject as a prize essay, and which was gained by the celebrated Desmarest, then a young man. His principal arguments are founded on the identity of the structure and composition of the cliffs on the opposite sides of the channel;—on the submarine rocky chain extending from Boulogne in France to Folkestone in England, which is only fourteen feet under low water, and on the identity of the noxious animals of France and England, which could never have swam across the strait, and which would never have been introduced by man.

He also attributed the breaking down of the former isthmus to the preponderating violence of the current from the north.

Devastations by the Sea, on the South Coast of England.

Sussex.—The whole coast of Sussex has been incessantly encroached upon by the sea, from the earliest time known.

What arguments are adduced to show that France and England were once joined at the Straits of Dover?

During a period of no more than eighty years there are recorded notices of about twenty inroads of the sea on that coast, and in which tracts of land, from twenty, to *four hundred acres* in extent, were overwhelmed at once.

In the reign of Elizabeth, the town of Brighton stood near the place now occupied by a pier extending into the sea. In 1665, twenty-two tenements belonging to that town were swept away, and in 1703 and 1705, 113 houses were destroyed, which formed all that remained of the ancient town. At the present time not a vestige of the ancient town remains, the whole site being covered by the sea.

Inroads of the Sea in Holland.—One of the most memorable and destructive inundations of the sea on record, occurred in Holland in 1421. Owing to a great storm, the sea rose, and pouring into the united mouths of the rivers Meuse and Waal, burst through a dyke in the district of Bergse-Veld, and overflowed or destroyed seventy-two villages and 100,000 inhabitants. Thirty-five of these villages were so entirely swept away, or buried, that not even a vestige of their ruins were ever afterwards found, and the section of country where they stood, for centuries remained under water. It is now an immense plain having been gradually filled up by alluvial deposites from the river. It is still uninhabited, but yields abundant crops of hay.

The other villages, though many of them were nearly ruined, were not permanently submerged, and were afterwards repaired, or rebuilt.

We might proceed to fill a volume with similar accounts of the destroying effects of the sea in various parts of the world, but these examples are deemed sufficient to show the pupil in Physical Geography, in what manner and to what extent, the sea has made, and is still making, encroachments upon the land.

The changes produced on the face of the earth, in

What is said of the destruction produced by the sea in Holland? Which encroaches most, the land upon the sea, or the sea upon the land?

consequence of the accumulation of land in one place, and its destruction in another, have in the course of ages been very considerable. Whether the sea makes greater encroachments upon the land, than the land upon the sea, it is difficult to determine. The difference within the last two thousand years has not been such as to make any appreciable difference in the level of the sea, which by certain marks, consisting of works of art left by the Romans, is known not to have changed its level since the Christian era.

It has, however, been the theoretical opinion of several geologists, that the great basin of the ocean was gradually filling up, but no proofs except those of analogy, as the filling up of lakes, have been brought to show that this is the case.

It must be remembered that the millions of tons of alluvial matter which is every year carried into the sea, did it all remain there, would not in the course of thousands of years, make any appreciable difference in the level of a body of water covering seven tenths of the earth. But a great proportion of the matter swept into the ocean by rivers, is again cast upon the shores by the waves, so that, if the general level of its bottom is increasing, it must be at a rate so gradual as for ages to make no difference which we can by any means detect.

IGNEOUS CAUSES.

Having thus, as far as the design of this work will allow, given examples of the effects of water, both running, and in the form of sea waves, in changing the face of the earth, we now come to the subject of *Igneous* causes, and to the inquiry, how far volcanoes, and earthquakes have changed the earth's surface.

We have seen that the action of rivers, and of the sea, on certain coasts have continued from the earliest periods of which we have any records; and we may infer from the effects produced in many instances, that

How is it known that the level of the sea has not changed in 2000 years?

these causes commenced long before any account of their effects has been given. So also with respect to the action of igneous causes, the earliest records of history, furnishing proof that certain districts were then subject to catastrophes from volcanoes and earthquakes, and which are still known as volcanic districts. Certain indications in various places, prove also, that these causes had been in action long before the records of history commenced.

With respect to the *Theory* of earthquakes, we must refer the student to another part of this work, merely stating here, that they may depend on the existence of subterranean fire, or matter in the state of fusion, at an unknown depth beneath the surface of the earth.

Earthquakes and volcanoes undoubtedly depend on the same cause. This seems to be proved by the fact, that when an earthquake happens in the vicinity of a volcanic mountain, the earthquake commonly ceases when the eruption of the mountain begins, or when the confined matter which caused the motion of the earth, finds an outlet.

Number of Volcanoes on the Earth.—The number of volcanoes known to exist is about 200, more than one half of which are on the American continent.

Volcanoes, in most instances are situated near the sea, the only known instance to the contrary, being that of Jorullo, in the Andes of South America, which is about 100 miles inland.

Nearly one half of all known volcanoes are situated on islands, those of America being the chief exceptions to this law.

Prof. Jameson gives the following estimate of the number of volcanes, and their situations.

What is the cause of volcanoes and earthquakes? Why is it believed that volcanoes and earthquakes have a common cause? What is the number of volcanoes on the earth? What is the general situation of volcanoes with respect to the sea? What is the number of volcanoes on the earth?

On the continent of Europe, - - -	1
On islands of Europe, - - - -	12
On the continent of Asia, - - - -	8
On islands of Asia, - - - -	58
On the continent of America, - - -	97
On islands of America, - - - -	19
	195

Of this number, it appears that 106 are situated on continents, and 89 on islands. The only volcano on the continent of Europe, is Vesuvius, in Italy.

GEOGRAPHY OF VOLCANOES.

It is a fact, which by no means can be explained, that the great ranges of mountains in Europe, Asia, and Africa are generally destitute of volcanoes, while corresponding ranges in America, contain nearly half the volcanoes on the globe.

Africa does not afford a single burning mountain, except that of Teneriffe. And in Asia and Europe, no mountain belonging to any considerable range, except a single one in Kamtschatka, sends forth flames.

A great proportion of the earth is entirely without these tremendous agents, while certain districts in some instances amounting to a great extent, are in constant danger of being overwhelmed, or swallowed up by their effects.

The greatest, or most extensive chain of volcanic mountains are those of South America. If a line be drawn round the Pacific Ocean, so as to include these mountains on the west of America, and the Asiatic Peninsula of Kamtschatka, together with the islands of Sumatra and Java, we shall have within the semi-circle, the grandest volcanic system on the globe.

From Terra del Fuego, (*the land of fire*) there is

How many are situated on islands, and how many on continents? What is said of the volcanoes on the great ranges of mountains in Europe, Asia, and Africa? Where is the most extensive volcanic chain of mountains?

nearly an uninterrupted chain of volcanoes, to the peninsula of Alaska, a distance of 4000 miles. From Alaska, the Aleutian islands, which stretch towards the opposite peninsula of Kamtschatka, contain several volcanoes, and Kamtschatka itself several more. The Islands of Japan and Formosa, as well as Sumatra and Java, and indeed a great portion of that great Archipelago, of which they form a part, are volcanic islands.

Standing on the Island of Borneo, under the equator, and looking towards the north east, and then turning to the right, until the face is towards the north west, the spectator would in successsion face one continued circular chain of volcanic islands, beginning with the Philippine Islands, and ending with Nicobar, at the northern extremity of Sumatra.

The principle islands in this volcanic system, besides the Philippines, are the Moluccas, Java, and Sumatra. But between these, there is a vast number of small islands scattered throughout the whole circle, many of which are subject to the most terrific volcanic eruptions. Among them is Sumbawa, which in 1815 suffered one of the most tremendous, and destructive eruptions on record.

Besides these volcanic systems, there exists many isolated districts, where one or more burning mountains are to be found. Among these, are Italy and Sicily, Iceland, Portugal, the Azores, a part of Bengal and some of the West India Islands.

PHENOMENA OF EARTHQUAKES AND ERUPTIONS.

The Italians, who are but too well acquainted with these terrible phenomena, distinguish earthquakes into three kinds, according to the direction of the motions which they give the surface of the earth.

First. The *horizontal* motion, consisting of undulating vibrations of the earth, similar to the motions of the roll-

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What islands compose the great system of volcanic islands in the Indian and Pacific Oceans? What other volcanic districts are mentioned?

ing sea. During the great earthquake which destroyed Lisbon, these undulations, or waves of the earth followed each other at the distance of about ten feet. *Second.* The *vertical* motion, in which the earth is lifted up, with a sudden and perpendicular movement, at one place, and then immediately let down, sometimes far below its former level. During an earthquake in Calabria, this motion was so sudden, that flat paving stones were inverted by being tossed into the air. *Third.* The *whirling*, or *vorticose* motion. This is the most extraordinary, and unaccountable of these motions. We may well conceive how the earth, by a sufficient subterranean power might be elevated perpendicularly, or thrown into wave-like motions. But by what direction of force, a small section of ground can be made to whirl round on a centre, it is difficult to conceive; and yet that such a motion took place in the ground at Calabria, during an earthquake, was proved from the fact, that stones lying horizontally on each other, were some of them turned half round, without being thrown down.

Effects of Earthquakes.—By far the most dreadful agents in existence, in producing changes upon the surface of our globe, are those convulsive movements which are above described. In a moment they have devastated the fairest, and most happy regions of the earth, and overturned the proudest monuments of human industry and genius.

From the earliest records of history down to the present time, the most delightful, and highly cultivated portions of Italy, have at intervals been either overwhelmed, and buried by rivers of burning lava, or to a great extent, in all directions, covered by volcanic ashes.

The face of the country in the vicinity of Vesuvius, has from time to time, been so changed by such catastrophes as hardly to be recognised. Valleys have been filled, mountains elevated, and whole districts changed in a day, from gardens to deserts.

What are the three kinds of motion into which the earth is thrown by earthquakes?

The eruptions of Etna, and the earthquakes of Sicily, have in like manner, at different periods produced the most frightful changes in that fertile island.

The great earthquake of 1755, which destroyed the city of Lisbon in Portugal, and swallowed up 60,000 of its inhabitants, was felt over nearly one half of the globe. In Africa, the same convulsion buried in one town 10,000 people. The sea, at the same time, overflowed several coasts to a great extent, and besides sweeping away thousands of inhabitants with their houses and cattle, produced material changes in the form of the land. Mountains were also rent asunder, and their summits precipitated down their sides.

In 1783, an eruption of Skaptar Jokul, in Iceland, threw out such a quantity of lava as to cover several thousand square acres of surface, which to this day remains a barren rock. The lava dammed up several rivers by crossing their channels, and thus drowned the inhabitants, one fifth of which were destroyed.

The eruption of Sumbawa, one of the Molucca Islands, in 1815, destroyed nearly all the inhabitants of the island, and buried its entire surface, under volcanic ashes. But we reserve a more particular account of these and other devastations, for a future place.

VOLCANIC ERUPTIONS.

A *Volcanic Eruption* consists in the discharge of fire, smoke, lava, and volcanic ashes from the summit of a mountain. Some mountains emit all these in succession, or several at the same time, while others, or the same mountain at other times, sends forth streams of fire and smoke only. Commonly, however, the smoke and flames are succeeded by a stream of lava, when the mountain is more strictly in an actual state of eruption.

In general, eruptions take place at uncertain intervals, the volcano often remaining dormant for many years,

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What does a volcanic eruption consist in? Are there any fixed periods of eruptions or not? How long has Stromboli been on fire? What is said of the eruptions of Vesuvius? What phenomena precede an eruption?

or even in some instances for centuries, and then again bursting forth, and producing dismay and destruction on all sides.

Stromboli, one of the Lipari Islands, on the contrary, sends forth flames perpetually, and has continued to do so from about 300 years B. C. thus, serving as a natural lighthouse, which it has done for ages.

Vesuvius suffered 28 eruptions from A. D. 27 to 1771, making an average of nearly one eruption in 60 years. But sometimes centuries have elapsed without an eruption of this mountain.

Phenomena of Eruptions.—A shaking, rolling, or trembling of the earth is usually felt before an eruption. Sometimes these sensations are felt at the distance of many leagues in all directions from the volcano, and are often accompanied, or immediately followed, by loud deep-toned, rumbling noises like distant thunder, coming from the earth.

The cattle and horses in all volcanic districts, on hearing these warnings immediately take the alarm and fly in the wildest manner in all directions. Though no eruption had happened in many years, and these animals had never before heard such sounds, still it is said, their agitation is not the less, being taught by instinct that such sounds portend destruction.

After the continuance of these premonitory symptoms for an uncertain time, and which are often attended by sudden shocks more or less violent, there darts up from the mountain immense volumes of black smoke, attended by flashes of the most vivid lightning, which add greatly to the terror, and splendor of the scene.

After the appearance of these phenomena, often attended by the shooting of red hot stones and rocks to an immense height, the lava begins to run over the margin of the crater in the form of a river of fire, descending to the plains with greater or less rapidity.

What is said of the velocity with which lava runs? To what height is it said stones are sometimes thrown from a crater? How far was the heat of Vesuvius felt? What was the effect when a stone of 300 pounds fell on the flowing lava?

The lava sometimes runs with considerable rapidity, but more commonly its progress is slow, the last portions running over the first, in small cascades, except where the declivity is steep.

The eruption of lava is sometimes attended, but more often followed, with showers of ashes, which consist of finely divided particles of the lava, and which are often wafted to the distance of several hundred miles by the wind.

Sir Wm. Hamilton, who witnessed the great eruption of Vesuvius which happened in 1779, states that the jets of liquid lava from the mountain, mixed with stones, were thrown to the height, of at least 10,000 feet, having the appearance of one continuous column of fire.

The falling matter, he continues, being nearly as vivid as that which was constantly issuing fresh from the crater, formed with it one complete body of fire, which could not be less than two miles and a half in breadth, and of the height above mentioned, casting its heat, at least six miles around in all directions.

Dr. Clarke, who witnessed an eruption of the same mountain in 1793, says that the lava issued in a torrent from a chasm in the side of the mountain, with the velocity of a flood, flowing with the translucency of honey, and glowing with all the splendor of the sun.

This current was still so dense, that small stones falling upon it from the mountain made little impression, but a rock, apparently weighing three hundred pounds, which was thrown from the crater, and fell upon the lava, gradually sunk down, as it floated along, and disappeared, being melted and dissolved by the heat.

VOLCANIC CONES AND CRATERS.

The *cone* of a volcanic mountain, is its apex or peak, from the centre of which the lava issues. This portion of the mountain increases in elevation during eruptions

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What is the cone of a volcano? How is the cone measured in height?

by portions of the lava which cools there, and also by the fall of rocks and ashes.

There is a considerable difference in the form of this part of a volcano in different mountains, and in the same mountain at different times.

Sometimes the cone continues to increase in height, and preserving its conical shape, appears at a distance to terminate in a point. But at the next eruption, this part is sometimes shattered in pieces, and thrown down the sides of the mountain.

A common appearance of a volcanic cone is represented by Fig. 19, being that of Etna, on the Island of Sicily.

The sides are covered with rocks, and lava in large masses, while the peak is composed of ashes, stones, and

Fig. 19.

lava in smaller masses. Within the cone is the *crater* of the volcano. This is in the form of a disk, over the edges of which, the lava flows when it rises to the top of the mountain, for sometimes the pressure is such that

Where is the crater of a volcano? What is the appearance of a truncated cone? In what manner did the cone of Vesuvius become truncated?

it bursts the mountain asunder, and flows from a fissure in the side.

Craters differ greatly in dimensions in different mountains. That of Vesuvius at present is about three miles in circumference, and from one to two thousand feet deep. Those of some other mountains are two or three times this size, while others are much smaller.

When the top of a volcanic mountain is flat, or wants a pointed summit, it is said to be *truncated*, or to have a truncated cone, Fig. 20.

The cone of Vesuvius in 1822, became truncated in consequence of the explosion during an eruption, breaking up, and throwing down large portions of its ancient

Fig. 20.

crater, so that eight hundred feet of its cone was carried away, and the mountain was reduced from an elevation of about 4,200, to 3,400 feet.

The cones of volcanoes become truncated from another cause, namely, the sinking of the cone into the abyss, or cavity of the mountain.

A terrible instance of this took place in a volcano of Java, called Papandayang, in 1772.

During an eruption, and before the inhabitants on the sides of the mountain could make their escape, the

What account is given of the truncation of a volcanic cone in Java?

ground gave way, and a great part of the volcano fell in and disappeared.

This was one of the loftiest volcanoes of Java; and the ground to the extent of fifteen miles in one direction, and six, in another, was swallowed up, destroying with it forty villages, and nearly three thousand inhabitants.

The figure (20,) represents a volcanic mountain in Iceland, which from the resemblance of its cone to a vast artificial fortification, is called in the Icelandic language *Elldborg*, or "the fortress of fire."

Dr. Henderson, after much difficulty ascended its summit, and was not a little alarmed when he had attained his object, to find that he was only separated from the tremendous abyss of its crater, by a dome of lava, in many places, not exceeding six inches in thickness.

The wall on the inside was in many places nearly perpendicular, and about 200 feet high from the bottom of the crater. The crater terminated in a small aperture exactly in its centre, from which the burning flood formerly issued, spreading devastation and ruin on all sides. This crater is 1800 feet in circumference.

CHANGES PRODUCED BY ERUPTIONS.

Eruptions of Vesuvius.—Mount Vesuvius is about thirty miles in circumference, and 3,400 feet in height, and is situated seven miles east from the city of Naples. This district is naturally among the most delightful, and fertile in that country. But the vicinity of the mountain, has ever since the records of history, been subject to the most terrible devastations from earthquakes and volcanic eruptions.

In A. D. 79, the two large cities Herculaneum and Pompeii were overwhelmed and buried at one eruption. These were both sea ports.

The latter city stood nearer the mountain than the former, but in a different direction, and was not destroy-

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What description is given of the crater of Elldborg in Iceland? What is the circumference of Vesuvius?

ed by the same current. But neither of these cities were buried in burning lava, as is generally believed, but by volcanic mud, or by ashes of the mountain brought down by a deluge of rain.

Had these cities been overwhelmed by red hot lava, the casts, or impressions of various utensils destructible by fire, would not have remained, as the utensils themselves would have been destroyed; whereas the forms of various articles, and even those of persons still remain impressed in the matter with which the cities were filled.

There is decisive evidence that no stream of lava ever reached Pompeii since it was first built. But with respect to Herculaneum, though the matter which filled the houses must have been introduced in the form of mud, like that of Pompeii, yet the superincumbent mass is entirely different from that which overwhelmed that city, being composed of volcanic ashes, and streams of lava. These accumulations above the city are nowhere less than seventy, and often more than one hundred feet deep.

In 1731, another eruption destroyed the town of Torre del Greco, with 3000 inhabitants. In 1737 and 1794, this ill-fated town was again overwhelmed, many of its inhabitants destroyed, and most of the houses burned up, or imbedded in a mass of solid lava.

At present this very lava which annihilated the former town is quarried to build houses over those which it had destroyed, and Torre del Greco again contains 15,000 inhabitants.

Besides the changes produced in the neighborhood of Vesuvius by eruptions of lava and the fall of volcanic ashes, there have been other, and still more remarkable changes by the sinking of the earth in some places, and its elevation in others, but more especially by the latter.

In 1538, a new volcanic mountain was formed near the shore of the Bay of Naples, by the rising of the earth, and by the fall of stones, pumice, and ashes, from

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What were the volcanic products which destroyed Herculaneum and Pompeii? How is it shown that they were not destroyed by burning lava?

a fissure through which they were forced by volcanic action. This mountain in the course of 36 hours attained the height of 440 feet above the level of the Bay.

Eruptions of Etna.—Mount Etna is situated on the Island of Sicily, in N. L. 38°. Its circumference at the base is about 80 miles, and its height 11,000 feet.

Division of Etna into three Regions.—This mountain is naturally divided into three zones, called the *fertile*, the *woody*, and the *desert* regions.

The first comprising the base of the mountain, is highly cultivated, thickly inhabited, and covered with olives, vines, and fruit trees.

The second or woody region, next encircles the mountain, and consists of extensive forests six or seven miles broad, affording pasturage for numerous flocks. The wood consists of beech, oak, chesnut, and pine.

The third region, being still more elevated, has neitheir vines nor fruit trees, but presents a barren waste, with a surface beset with blocks of lava, volcanic slags, and ashes.

This mountain was an active volcano from the earliest times, an eruption being recorded which happened nearly 500 years before the Christian era.

An eruption which happened in 1669, caused a fissure in the earth about 20 miles from the summit, from which issued such a quantity of volcanic matter as to form a mountain 450 feet high. At the same time, the earth was rent asunder, and a chasm formed six feet broad, and of an unknown depth, nearly to the summit of the mountain. It emitted the most vivid light, and the phenomenon was attended with the most horrid subterranean sounds which were heard to the distance of 40 miles.

The mountain thus formed had a double cone, and is

What town did the eruption of 1731 destroy? What is said of that town at the present day? What other changes in this vicinity have been made by volcanic power? What are the three zones, or regions of Mount Etna?

represented by Fig. 21, as drawn by a recent traveller. It is called Monte Rossi, and stands near the town of Nicolosi.

Meantime the lava poured forth from a fissure near Monte Rossi, and taking a course towards the city of Ca-

Fig. 21.

tania, destroyed in its way 14 towns and villages, some of them having a population of 3000, or 4000 inhabitants.

The Catanians, as a protection against such an event, had erected a wall towards the mountain sixty feet high, but the burning flood, continuing to accumulate, finally poured over the wall in a cascade of fire, and overwhelmed and destroyed all that part of the city.

Eruption of Skaptar Yokul in Iceland.—This awful calamity happened in 1783, and the quantity of lava which the mountain threw out was so enormous that the two currents, which ran nearly in opposite directions, reached the distance, one of forty, and the other of fifty miles, with a breadth varying from seven to fifteen miles. The depth of the lava was ordinarily about one hundred feet, but in crossing narrow defiles it was

How early are eruptions of Etna recorded? What is said of the formation of Monte Rossi, and the destruction of the eruption in 1669? What was the quantity of lava emitted by Skaptar Yokul in 1783?

sometimes six hundred feet deep, and two hundred in breadth.

Dr. Henderson, who visited the spot in 1814, gives a most melancholy account of the devastation committed by this burning flood. Of a population of about 50,000, more than 9,000 were either destroyed by the burning lava,—drowned by the damming of rivers, which the lava crossed, or died of starvation afterwards. Of the animals nearly 30,000 horses, 11,000 cattle, and 200,000 sheep perished.

The quantity of ashes and brimstone thrown into the air was so great, that nearly the whole of Europe was enveloped in obscurity, and luminous meteors from the same source, were observed in England, Holland, and on the continent.

Eruption of Mount Tomboro.—An eruption fully equal to that of Skaptar Yokul, in some of the tremendous phenomena which attended it, took place from Mount Tomboro, situated on the Island of Sumbawa, one of the Moluccas.

This eruption began on the 5th of April, 1815, but was most violent on the 11th and 12th of that month, at which time the explosions were heard at Sumatra, a distance of 1000 miles, and at Ternate, in the opposite direction, at the distance of more than 700 miles.

On the island there were 12,000 inhabitants, of which only 26 individuals escaped with their lives.

At the distance of 40 miles, the fall of ashes was so heavy as to crush down the roofs of houses, and at Java, 300 miles distant, such was the darkness occasioned by the ashes, that at noon, it was more profound than the darkest night ever witnessed.

The whole island was covered with a thick bed of ashes, and large tracts with streams of lava. The bottom of the sea in the harbor was elevated, so that vessels lying in 30 feet of water were grounded.

What number of people and animals were destroyed? To what distance were the explosions of Tomboro heard in different directions? What was the amount of human destruction of the island?

Remarks.—The above are only a few among the examples which might be brought of the awful phenomena which attend volcanic eruptions. The force of expansion by heat is undoubtedly without limits, but man never could have had the least conception of its effects, had he not witnessed it in the action of volcanoes. The power, necessary to project rocks of three or four hundred pounds weight from thousands of feet below the surface of the earth, to at least a mile above it,—as was the case in some of the eruptions of Vesuvius, or to elevate a river of lava, having at least twice the specific gravity of water, from beneath the crust of the earth, as in the eruption of Shaptar Yokul, is altogether beyond our calculation, or comprehension.

The mystery too, in which the subject of eruptions is enveloped, is not a little calculated to excite the constant apprehensions of those who inhabit volcanic countries. The time of an approaching catastrophe when whole districts under the highest cultivation, shall be laid waste, and thousands of its inhabitants in a moment hurried to their final account, no mortal can foresee. In many instances, after centuries of inactivity, volcanoes have suddenly burst forth with a degree of violence, apparently proportionate to the time they have lain dormant, and in a moment prostrated the most enduring works of art, and forever rendered sterile, the most highly cultivated districts.

And yet men become so habituated to the inspection of such scenes, and their consequences, that so soon as the lava, which covered their habitations gets cold, they again begin to quarry it for the erection of new ones in the same place. Thus Torre del Greco stands on the same spot of the ancient town, and is built of the lava which destroyed it, and the ancient Herculaneum stood on a stream of lava, which came from the same mountain, that afterwards proved the source of its final destruction.

Frequency of Volcanic Eruptions.—During the last

How many volcanic eruptions took place in Europe during the last century?

century about fifteen eruptions are recorded to have happened in the five volcanic districts of Europe, viz. Vesuvius, Etna, Volcano, Santorin, and Iceland.

Now, if we consider the active volcanoes of Europe as constituting about a fortieth part of those on the globe, and calculate that one with another, they are about equal in activity to the burning mountains in other districts, we may then compute that there happens on the earth, about two thousand eruptions in the course of a century, or about twenty in each year.

The amount of changes on the surface of the earth which these produce, or have produced, is a problem which we have no means of determining. But from the examples above given, these must, in volcanic countries, be very material.

ISLANDS RAISED FROM THE SEA.

The instances in which islands have been elevated from the bottom of the sea in different parts of the world are very numerous; and undoubtedly, in many cases, where mariners have found shoals, in places formerly navigable, the cause may be attributed to volcanic action, though no one had happened to witness its phenomena.

The ancients have recorded several instances of the rising of islands out of the sea, attended with fire and smoke. But we shall advert only to such cases as are known to have happened, and of more recent date.

In 1783, during the eruption of Skaptar Yokul, an island of considerable size rose off the coast of Iceland, which was claimed by his Danish Majesty. But in the course of the year it entirely disappeared.

In 1757, eighteen small islands were elevated from the ocean in the vicinity of the Azores.

In 1706, there arose from the sea, a new island among the Aleutian group, north of Kamtschatka.

This was four miles in circumference, and from its

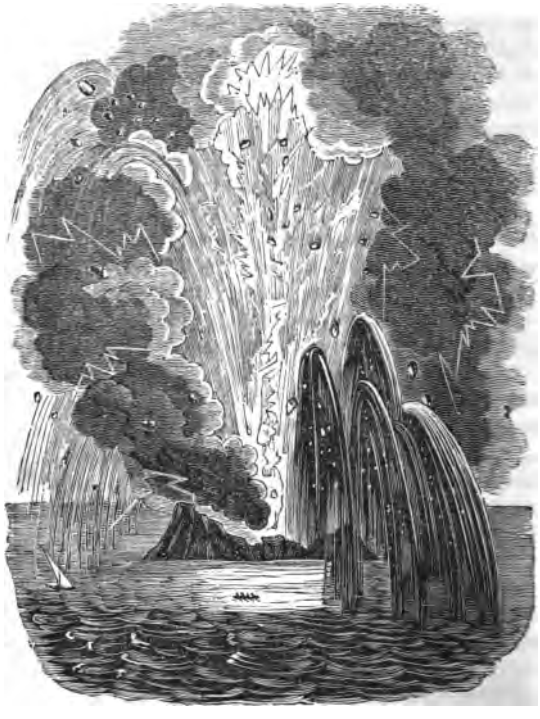
What number are estimated to have happened on the earth during the same period? How many in each year?

not subsiding, as most such islands have done, is supposed to consist of solid rock.

Elevation of Sabrina.—In 1820, a new island was raised from the sea, and added to the Ionian group, on the coast of Greece.

In 1812, off the coast of St. Michael's, one of the

Fig. 22.



Azores, there rose a volcanic island, where the water was 90 feet deep, and continued to increase until it be-

What is said of the instances in which islands have risen from the sea? Is it not probable that shoals are formed by volcanic forces? Mention some of the principal islands which rose from the sea.

came 400 feet in diameter, and 200 feet above the level of the sea.

The elevation was attended by immense bodies of smoke, flashes of lightning, and other volcanic phenomena, and which were witnessed by Capt. Tillard of the British navy, who called the island *Sabrina*, the name of his ship.

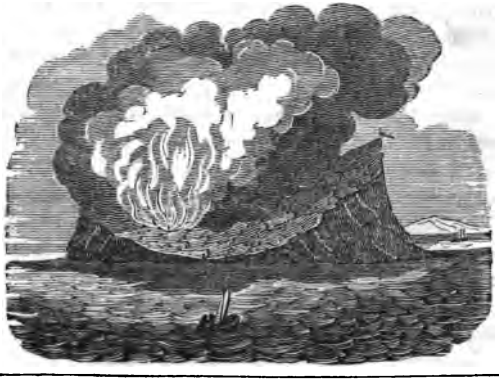
This island had a regular volcanic crater, but being composed of ashes, and pumice, it was soon washed away by the waves, and entirely disappeared.

Graham Island.—In 1831, an island rose from the sea, on the north west coast of Sicily, where the water had before been 300 feet deep. This was called Graham Island.

Before the appearance of this island, a mariner reported, as he passed near the place, that he saw a column of water rising sixty feet high, like a water spout, —that it was 800 yards in circumference at the base, and that a dense steam ascended from it to the height of 1800 feet. This appearance is represented by Fig. 22.

A few days after, there appeared at this place a small island, twelve feet high, with a crater in the centre, from

Fig. 23.



How do changes produced by eruptions and those by earthquakes differ?

which there issued volcanic matter, and an immense quantity of vapor.

This island continued to increase for about a month, when it became about 200 feet high, and three miles in circumference. It then had the form and appearance represented by Fig. 23.

It afterwards began to diminish, and on the 25th of August, about six weeks after its first appearance, it was only about 100 feet high, but its crater at this time was 800 feet in circumference.

Towards the end of October, no vestige of the crater remained, and the island was nearly leveled with the surface of the sea. But in 1833, the remains of this island still existed, forming a dangerous reef more than half a mile in extent.

CHANGES PRODUCED BY EARTHQUAKES.

The changes produced by eruptions, and earthquakes differ materially from each other. Eruptions, as we have seen, cover the surface with lava, or ashes. But the effects of earthquakes are to change the level of the ground without otherwise altering the appearance of its surface.

Phenomena preceding Earthquakes.—It is a singular and mysterious circumstance, that there are certain atmospherical phenomena which precede earthquakes, but which to all appearance, can have no possible connection with their cause. These appearances are observed with the most anxious solicitude in all volcanic countries, and experience seems to show that they are undoubted prognostics of an approaching convulsion. The following are said to be the most common.

Sudden gusts of wind succeeded by dead calms.

Violent rains at unusual seasons, or in countries where rains are generally unknown.

Irregularities of the seasons preceding the shocks, or following them.

What is said of the connection between atmospherical phenomena and earthquakes?

A reddening of the sun's disk, or a haziness in the atmosphere, sometimes continuing for months before the event.

An unusual quantity of electric matter, as exhibited by sudden thunder squalls; also, an evolution of inflammable, or sulphureous gas from the ground.

Noises proceeding from the earth, resembling the rumbling of carriages, or of distant thunder.

Earthquake of Chili.—In November, 1822, the coast of Chili in South America, was visited by an earthquake, which was felt at the same time to the distance of 1200 miles from north to south.

St. Jago, Valparaiso, and many other places, were greatly injured by the shock, and the next morning, it was found that the whole line of coast to the distance of more than 100 miles was raised above its former level. At some places the elevation was 3 feet, and other places 4 feet.

Extent of Country elevated.—The area over which this permanent change of level is supposed to have extended, is about 100,000 square miles.

If we suppose the elevation to have been equal to three feet on the coast, Mr. Lyell estimates that the mass of rock added to the American coast by this movement, or in other words, the mass previously below the level of the sea, and after the shock permanently raised above it, must have been equal to fifty-seven cubic miles in bulk; which would be sufficient to form a conical mountain two miles high, or about the height of Etna, with a circumference at the base of thirty-three miles.

If we take the specific gravity of this mass at 2.655, a fair average, and a convenient one, because at this rate, a cubic yard weighs two tons, then assuming the great Pyramid of Egypt, if solid, to weigh, according to

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What are the atmospherical phenomena which precede earthquakes? To what extent was the coast of Chili raised by the earthquake of 1822? What are the estimates of the quantity of rock thus added to the Chilian coast?

a former estimate, six millions of tons, the rock added to the continent, by being elevated above the water, will be equal to 100,000, such Egyptian pyramids.

But the rock thus added to the coast constitutes but a fractional part of the amount which the volcanic force had to overcome. It is true that we can only conjecture how far beneath the surface, the volcanic force was applied; it may have been many miles, but supposing it to have been only two miles, then the whole mass thus elevated would be equal to 200,000 cubic miles of solid earth in volume, which would exceed in weight, 360 millions of Egyptian pyramids.

Earthquake of Cutch.—In 1819, a violent earthquake happened at Cutch, a district situated near the mouth of the Indus, in Hindostan, which converted the capital, Bhooj, into ruins. It was also felt with such force at the great city of Amedabad, several hundred miles distant, as to throw down the great mosque erected there by Sultan Achmed, and which had stood 450 years; a proof that the cause of earthquakes, whatever it may be, may lie dormant for centuries, and then in a moment spread devastation and ruin in all directions.

After this convulsion, it was found that the land of Sindree, on the eastern arm of the Indus, had sunk down, so that the sea flowed in by that arm, and in a few hours, converted a tract of land 2000 square miles in area into an inland sea.

Another effect of this earthquake, was to elevate an extensive tract of land *fifty miles* in length, on the east of that which had subsided, and parallel with it, running east and west. The breadth of the elevated portion was about sixteen miles, and its present height above the original level about ten feet.

Earthquake of Caraccas.—In 1790, there happened an earthquake in the territory of Caraccas, on the eastern coast of South America, during which the rocks and

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What is the estimate of the quantity of land elevated by the Chilian earthquake? What were the effects of the earthquake of Cutch?

soil sank down and left a lake more than half a mile in length, and from 80 to 100 feet in depth. It being a portion of a forest which subsided, the trees for many months presented the singular spectacle of standing, green, and erect under water,—a submerged forest.

Earthquake of Calabria.—This was one of the most destructive earthquakes on record, and happening in the midst of a thickly populated country, and among men of science, and especially as the shocks continued for nearly four years, it has been better described than any other.

Calabria is a province of Naples, and forms the southern extremity of Italy. The earthquake, some of the effects of which we are about to describe, began in February, 1783, and the shocks continued at intervals to the end of the year 1786.

During the first year, when the destruction was greatest, the number of shocks was 949, of which 500 were of the first degree of force; and in the following year, the number was 151, of which 98 were of the first degree of force.

Extent of the Convulsions.—The area over which the shocks were felt, included the whole of Calabria Ultra, the south-east part of Calabria Citra, and the environs of Messina in Sicily.

Singular Effects of the Shocks.—The shocks were divided, by those who felt them, and saw their effects, into three kinds, the *horizontal*, *vertical*, and *whirling*, as already described.

The horizontal, or rolling motion, by which the earth was thrown into waves, like those of the sea, often brought on dizziness, and sickness at the stomach, symptoms precisely like those of sea-sickness.

The vertical motion, was often so violent and sudden as to throw detached masses several yards into the air.

During what years happened the great earthquake of Calabria? What were the number of shocks during the first year? How extensive were the convulsions in Calabria?

From this cause, in some of the towns, the flat paving stones were to a considerable extent, found lying with their lower sides uppermost, having been tossed up and turned over in the air.

The whirling motion, as already explained, sometimes had the effect of giving heavy bodies a circular movement. The effect was singularly shown by the appearance of a pair of obelisks at the convent of St. Bruno. The pedestal of each obelisk remained in its original place, but the separate stones were turned partially round, and some of them moved eight or ten inches out of their places, but none of them were thrown down.

Fissures in the Ground.—In some places fissures opened in the ground, so wide as to swallow up houses, and the moment the shock ceased, closed again so entirely as not to leave a vestige of what had happened, nor were any signs of such buildings ever seen afterwards.

In one instance a ravine was formed a mile in length, 100 feet broad, and 30 feet deep. In another the fissure was more than 200 feet deep.

In some cases the earth was *lacerated* in a most extrarordinary manner, the fissures running in every direction, like the cracks of a broken pane of glass. These fissures in many instances remained open.

Formation of Lakes.—In the vicinity of Seminara, a lake was suddenly formed by the sinking of the earth, which was 1785 feet in length, by 937 in breadth, and 52 feet in depth. Soon after the sinking of the earth, the water flowed in from the bottom, by which a permanent lake was formed, which remains to this day.

Such was the number of lakes formed in different parts of the country during these terrible convulsions, that some time afterwards, when it is probable many of the small ones had been filled up, the government surveyors reported their number to be 215.

What is said of the fissures made by this earthquake?

Land slips.—From each side of the deep valley called Terrnawood, at the bottom of which flowed a small river, enormous masses of the adjoining flat country were detached, and cast down into the river, which being dammed up, the water formed a number of large lakes; oaks, olive-trees, vineyards, and corn, were all seen growing luxuriantly at the bottom of the ravine, as little injured, when above the water, as their former companions, which continued to flourish on the hills.

In one part of the ravine was an enormous mass of earth, two hundred feet high, and four hundred feet at the base, which had travelled from its original locality, about four miles down the ravine.

The writers at the time, described and figured the scenes of desolation which this earthquake caused at great length, several volumes, with a great number of plates, having been published on the subject; but we must only add, that the number of towns and villages which were either totally destroyed, or much injured, were 15, and the number of inhabitants suddenly killed by the falling of the buildings, or by being precipitated into chasms, were 40,000; besides which 20,000 perished by epidemics, which were occasioned by the noxious vapors arising from the new lakes and pools of water which became stagnant in that warm climate; thus making the number destroyed 60,000.

Earthquake of Lisbon in 1755.—This earthquake is perhaps more frequently mentioned than any other; and on some accounts was more extraordinary than any, of which records have been made.

Without being in the vicinity of any volcanic mountain, or district, the people of Lisbon heard a sound as of thunder issuing from the ground, and immediately a shock of the earth followed which levelled a greater part of that city, and in the course of six minutes killed sixty thousand persons.

During the first shock, the sea retired, and laid bare

What was the amount of destruction by the earthquake of Calabria? In what year was Lisbon destroyed by an earthquake? What were the first effects of the earthquake of Lisbon?

the bottom of the bay; it then returned in a wave, of at least fifty feet high, overwhelming the coast, and carrying away thousands of persons, never to return.

To avoid death, by the fall of their buildings, the people collected on the quay, a new and splendid structure, then just finished. The number there, seeming to point that out as a place of the greatest safety, others ran to the same, until a vast concourse had assembled on that spot, when suddenly the quay itself sunk down, with all the people on it, and not one of the bodies ever floated to the surface. A number of boats also, filled with people, and anchored near the quay, were swallowed up as in a whirlpool, and not a fragment of these wrecks ever rose to the surface.

Area over which this Earthquake extended.—The distances to which the earthquake of Lisbon was felt, is one of its most remarkable features, there being no parallel in this respect on record.

The shocks were most violent at Lisbon, but were strong and fearful in most parts of Portugal, Spain, and the north of Africa. The cities of Fez, Algiers, and Morocco, were violently agitated, and at the distance of a few leagues from the latter, a village with 10,000 inhabitants and many cattle were destroyed.

It was also felt with greater or less violence in England, Scotland, France, and indeed, nearly throughout the whole of Europe. Even the West India Isles were convulsed, and shocks were felt on the same day on the continent of South America.

Earthquake of Peru.—The coast of Peru was visited by an earthquake in 1746, which was scarcely less violent and destructive than that of Lisbon. In the first 24 hours, 200 shocks were counted. The ocean retired and again returned in the form of a tremendous wave, which in the bay of Callao sunk and destroyed nineteen out of twenty-four vessels, with nearly all their crews,

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What is said concerning the reappearance of those persons and boats which sunk with the quay? To what extent was this earthquake felt? How destructive was the earthquake of Peru in 1746?

and the five others, among which was a frigate, were carried a great distance into the country.

The city of Lima was destroyed, and a part of the nearest coast sunk down, and was converted into a bay. Of 4000 inhabitants in Lima, only 200 escaped with their lives.

Earthquake of Sicily.—An earthquake happened in the island of Sicily in 1693, during which the city of Catanea, and forty-nine other towns and villages, were mostly levelled to the ground, and 100,000 people destroyed.

Fissures of the ground were produced in many places, and the stone buildings in the city of Noto to the extent of half a mile sunk into the ground, and there remained.

Earthquake of Jamaica.—In 1692, the island of Jamaica, one of the West India islands, was visited by a destructive earthquake, during which the ground heaved like a rolling sea, producing fissures so numerous that hundreds were seen at the same time opening and closing as the wave passed on. Many people were caught in these fissures and crushed to death.

At Port Royal, the capital, the ground sunk down so suddenly that the people had no time to escape, and three quarters of the houses with their inhabitants, were immediately covered by the sea.

A tract of land around the town subsided in less than one minute, during the first shock, so that the sea immediately rolled in, and covered a thousand acres.

The houses were many of them still standing, under the water, and some of them with their tops just above the waves. Some of them were submerged to a considerable depth, so that large ships were driven over their tops.

The mountains were also shaken, and in many instances strangely torn in pieces: and the rivers of these mountains first ceased to flow, and then brought down

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What account is given of the effects of the earthquake in Sicily? What changes were produced by the earthquake of Jamaica?

hundreds of thousands of tons of timber, mostly stripped of its bark and limbs in the descent.

These instances of the changes, and effects of earthquakes, the most tremendous and destructive agents with which our earth is afflicted, might be extended to a great length, but the cases described are sufficient to show that the surface of the globe has suffered, and is still suffering, the most important changes from this cause.

CHANGES PRODUCED BY AVALANCHES AND MOUNTAIN FLOODS.

The instances are numerous in which mountain slides, consisting of ice, or of earth, or both, have been the cause of filling valleys, of considerable extent, and the producing of local changes of more or less importance in different parts of the earth.

Destruction of Plurs.—Not a year passes away without the loss of life from the fall of ice among the Alpine mountains of Switzerland, and it appears that the inhabitants, thus exposed, like those of volcanic districts, do not take warning from past events, but in defiance of the laws of nature, build again and again, over the graves of their ancestors, while the same prospect of sudden death stares them in the face.

This was the case of the beautiful town of Plurs. It was built on the ruins of Belfort, which had been swallowed up by one of those sudden falls of ice and rocks so common in the Swiss Alps.

The new village was called *Plurs*, or "the village of sorrow," in commemoration of the death of its predecessor.

Plurs, though standing on the grave of Belfort, became one of the gayest, as well as richest villages in the Canton of Tessin, in Switzerland. It was the resort of the Italian nobility, and one of its hotels is said to have cost several millions of francs.

In September, 1618, when this town had reached the very summit of prosperity, and its inhabitants promised

themselves long lives, and an inheritance to their children, an unseen hand was at work in the mountain, which by the silent operation of natural causes, matured that fearful catastrophe, by which Plurs, like its predecessor, was destined to perish.

Great rains had fallen, and several symptoms of motion among the rocks and ice of the mountain had been observed; but still, the people of Plurs considered themselves safe, though warned by some of the shepherds of the mountains, that new fissures were forming there.

It is said also, that a holy man published in the market place, and proclaimed from house to house, that their destruction was at hand, and exhorted the people to flee for their lives; but that with the exception of his daughter, none heeded the prophet, and that even she, after having, with her father, passed the gate, went back for her trinkets, and perished with the rest.

About midnight, between the 3d and 4th of September, the surrounding country felt a tremendous shock, succeeded by a deep, hollow roar, like distant thunder, when again all was silent. This was the death signal of Plurs.

The people at a distance who heard the noise, saw, in the morning, that the sky was strangely obscured by clouds of dust, and vapor; and on approaching the spot, found, to their astonishment and dismay, that Plurs, the pride and ornament of the country, had entirely disappeared; the whole town being crushed, and buried so deep, that not a vestige, even of the tower of the church, was to be seen.

Every exertion was made to remove the rocks and earth, and to save, at least some of the victims; but all that strength, and perseverance, and ingenuity could do, availed nothing—not a single sufferer was disinterred—and of the whole population of Plurs, amounting to *two thousand five hundred*, only *three* individuals, who were from home, survived.

Miners were afterwards employed to excavate a passage to the Cathedral, which contained gold, silver, and jewels; but it was found that huge masses of rock, and earth, covered the whole to the depth of sixty feet, and

we are told, that the only relics of the wealth and luxury of Plurs, which were ever obtained, are a bell, and two lustres.

Fall of Rossberg.—Rossberg is on one of the high Alps, in the Canton of Schweitz, and forms a part of the bold, and beautiful scenery, so common in that romantic country.

In the summer of 1806 an unusual quantity of rain had fallen, and it was observed that new crevices were formed in the flank of Rossberg. Besides this, deep, confused, and rumbling noises were heard, portending some internal movement in the mountain; still the inhabitants in the vicinity did not take the alarm.

At length, on the 2d of September, a huge rock was hurled from its place down the mountain, and the pine trees were violently agitated, and twisted to and fro, while the birds flew from the vicinity, screaming with terror.

At five o'clock, still stronger indications of a fearful catastrophe became apparent; for the whole mountain appeared to be gliding towards the valley. Its velocity increasing with the descent, a vast mass fell into the valley below, overwhelming, and burying every thing in its way.

So great, and sudden, was the rush of earth and rocks into Lake Lowerz, though several miles distant, that its waters were driven in a single wave seventy feet high on the opposite shore, and in its return, swept houses, with their inhabitants, and cattle, into the lake.

This terrible avalanche overwhelmed four villages, of which the principal was Goldau, the largest in the valley of Art.

This village was buried to the depth of one hundred feet; and the only relic which remains of it, is the church bell, which, by the sudden shock, was thrown to the distance of a mile, where it was found.

Of the inhabitants, more than four hundred were buried under the mountain, of which fourteen only, were rescued alive.

The suddenness of this fall was such, that a pleasure

party consisting of seven persons, four being a little in advance of the others, entered Goldau, and shared the common fate, while the three escaped.

It is hardly necessary to detail similar instances, which from time immemorial have, at intervals, occurred in the chain of the Alps. In the Canton of Griscons, avalanches are so common as to be considered periodical scourges; hardly a season passing, without the filling of some valley, with a greater or less destruction of their inhabitants.

MOUNTAINS.

What we have hitherto said of mountains, has been in reference to their physical divisions of the earth, and to their heights. We now come to speak more particularly on this part of our subject, and to describe those belonging to each of the grand divisions of the globe.

General account of Mountains.—The eastern continent has a vast chain of mountains running nearly east and west, to the distance of 8000 miles. This chain is not entirely connected, but still may be considered as one great range passing through different countries under different names.

In Europe, it is called Alps, Pyrenees, Carpathians, and Appenines.

In Asia, it is called Caucasus, Himmaleh, Atlas, &c. It passes through Thibet, and Tartary, to the Pacific ocean. Etna, and the mountains of Greece, are branches of this general chain.

The heights of this chain in Europe, are from 4000, to about 15,000 feet; and in Asia, from 10,000 to 28,000 feet.

This great ridge determines the general form of the continent, and gives rise, and direction, to all the great rivers of the old world. This range of mountains has been called the *spine* of Europe and Asia; while the Andes are termed the "back bone" of America.

What is said of a great chain of mountains running through the eastern continent? What is this chain called in different countries? What is the height of this chain in Europe? What is their height in Asia?

To the north of this chain is the great plain which includes England, France, Holland, Germany, and Russia, to the Uralian mountains. This country is so level that it has been said, a ball, with sufficient force, would roll from Paris to Petersburgh.

South of this great chain lie the deserts of Africa and Arabia, and the plains of India; and the rivers Ganges and Indus are directed towards the southern ocean, as those on the opposite side are directed towards the northern ocean.

Chain of the American, or Western Continent.

In the western continent, there is a corresponding ridge of mountains, but running from north to south.

They begin at the straits of Magellan, in South America, beyond the 50th degree of south latitude, and continue their course to the distance of about 10,000 miles, ending in the Rocky Mountains, and Alleganies of North America, in latitude, north, from about 45 to 68 degrees.

This great chain gives direction to all the vast rivers on the continent, most of those in South America running towards the east, except the La Plata, which runs towards the south; while the Mississippi and its tributaries, passing between the Rocky mountains and the Alleganies, have also a southern direction, meeting in the great valley of the former.

It is said that there are 120 mountains on the earth which are more than 10,000 feet above the level of the sea, and 150 more which are from 5000 to 10,000 feet high.

MOUNTAINS OF SOUTH AMERICA.

The mountains of South America are among the most lofty and extensive on the globe.

The principal chain is the *Andes*, which runs along the

What is said of this chain in respect to the direction of the rivers? What countries lie to the north of this chain? What countries are south of the great chain of the eastern continent? In what direction does the great chain of mountains of the western continent run? What is the length of this chain? What are the principal mountains of South America?

western coast, from one to two hundred miles from the Pacific ocean.

The portion of this range which passes through Mexico, is called the *Cordilleras.*

This range is composed chiefly of granite, the summits being often capped with secondary rocks, as sandstone, and porphyry.

The whole range may be considered as volcanic, there being, with more or less interruption, a chain of burning mountains throughout their whole extent.

Among these are Chimborazo, and Cotopaxi, the height of the first being 21,000, and of the other 18,000 feet. These are the most lofty in the range.

MOUNTAINS OF NORTH AMERICA.

The mountains of North America, though in continuous ranges of great length, are not distinguished for their elevation.

The principal mountains in this division of the earth, are the *Rocky Mountains* on the west, and the *Apalachian chain,* including the *Allegany ridge,* and the *White Mountains,* on the east.

The Rocky Mountains begin at the Isthmus of Darien, and, as already noticed, are considered a continuation of the great range of the Andes.

By Humboldt, they are called the *Cordilleras* in their passage through Mexico; and of which the volcano, *Popocatapetl,* being 17,500 feet high, is the most elevated peak.

This range continues north under the name of the Rocky Mountains, to the arctic circle. The most elevated points in this portion of the range, are, James' Peak, 11,500 feet, and Long's Peak, 12,500 feet. These are near the sources of the Platte and Arkansas rivers.

On the west shore of America, a branch of this range

What are these mountains composed of? What are the highest mountains of the Andes? What are the principal ranges of mountains in North America? What name do the Andes assume in Mexico? What is the highest point of the Cordilleras? To what range do the Rocky mountains belong?

passes along the coast of the Pacific ocean, and terminates towards the north, in Mount St. Elias, which is 18,000 feet high, being the loftiest peak in North America.

The Apalachian chain commences north of the Gulf of Mexico, and east of the Mississippi river, and traverses the United States, with few interruptions, from the south-west to the north-east, through their whole length.

These mountains divide the streams which flow into the Atlantic ocean, from those which unite with the Mississippi, and pass into the Gulf of Mexico.

The Allegany Ridge is the central, or principal ridge of the Apalachian range. It assumes this name in Virginia, the same range being continued under the name of the Catskill Mountains, to the west bank of the Hudson river.

The White Mountains are a short range, only about twenty miles in length, in New Hampshire, ranging from north-west to south-east. Their highest peak is, for nine or ten months in the year, covered with snow, from which circumstance the name is derived.

These mountains are about 60 miles from the nearest coast, but their summits are plainly to be distinguished many leagues at sea.

The height of Mount Washington, the most elevated peak, is 6428 feet above the level of the sea.

MOUNTAINS OF EUROPE.

Europe presents a great number of mountains, which rise to the height of from 3000 to about 14 or 15,000 feet, but none to be compared in elevation to those of Asia and America.

What is the highest peak in North America? Describe the Apalachian chain. What streams does this range divide? Where is the Allegany ridge? Where are the White mountains? When are their summits covered with snow? What is said of the mountains of Europe generally?

The principal mountains of Europe are the *Alps*, the *Pyrenees*, the *Carpathian*, and the *Appenine* Mountains.

The Alpine Mountains are the best known, and the most celebrated range on the globe, being the constant resort of visitors, and men of science, from all parts of the world.

These mountains divide Italy, from Germany, France, and Switzerland. They are in the form of a crescent, and run from the Adriatic Sea to the Gulf of Genoa, where they unite with a branch of the Pyrenees.

This chain presents many peaks, which are from 6000 to about 14,000 feet in height. Mont Blanc, being the most elevated, is 15,668 feet high, and may be seen at the distance of 140 miles.

Mount Jura is a branch of the Alps, which extends north-east from Geneva, and divides Switzerland from France.

The Pyrenees divide France from Spain. This range extends from the Mediterranean to the Atlantic, at the Bay of Biscay, about 212 miles. Their greatest altitude is about 11,000 feet.

There are about fifty passes through these mountains, communicating between France and Spain, most of which are for mules and footmen, five only being passable for carriages.

Like the Alps, the Pyrenees are subject to slides, or avalanches, by which valleys are filled, and lives destroyed.

The Carpathian Mountains divide Hungary and Transylvania, from Poland on the north and north-east, and from Moravia on the north-west. The form of this chain is that of a crescent, and its length about 500 miles. The highest points do not exceed 8000 or 9000 feet.

What are the principal mountains of Europe? What nations do the Alps divide from each other? What is the height of the Alps? Where is Mount Jura, and what countries does it separate? What countries do the Pyrenees separate? Where are the Carpathian mountains? How high are the Carpathians?

The Appenines begin at the Gulf of Genoa, and, passing round that gulf, proceed east to the centre of Italy, thence in a south-east direction to the extremity of the kingdom of Naples. They thus divide Italy into two principal sections, and give direction to, and are the source of most of the rivers which water that country.

The Appenines are a branch of the Alps, but when compared with them, are mere hills. In many parts they bear the marks of volcanic fire, and are considered as once having formed a chain of burning mountains.

Besides the above, which are the principal mountains of Europe with respect to altitude, there is the *Scandinavian chain*, and the *Ural Mountains.*

The Scandinavian Mountains, or *Highlands*, as they are sometimes called, begin in Norway, and passing through Sweden, Lapland, and Finland, join the Uralian chain. That portion which separates Norway from Sweden, is called the *Norwegian Mountains.*

This range is about 1000 miles in length from north to south, but generally of small elevation, none of the peaks being more than 8000 feet high.

The Ural Mountains are a low range, which separate Europe and Asia, between the latitude of 50° and 67°, north. Their length is about 1200 miles, but no where exceed 5000 feet in elevation.

This chain continues through a part of Asia, and dividing into two ranges, one extends towards the *Altaian* mountains, and the other to the *Caucasians.*

The Ural chain is called by the Russians "the back of the world," and in some parts abounds in metals, and the finest marble.

MOUNTAINS OF ASIA.

Asia contains the most lofty mountains in the world, though the average of their altitudes is far below those

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Where are the Appenines situated? What is said of the volcanic appearances among the Appenines? Give some account of the Scandinavian, and Uralian mountains? What is said of the mountains of Asia generally?

of America, or even Europe. In America, some of the highest mountains are volcanoes, while Asia has only a single burning mountain. In general, much less is known of the mountains of Asia, than of those of Europe and America.

The principal mountains of Asia, are the *Himmaleh*, the *Altaian*, and *Ural* chains; and Mounts *Caucasus*, *Taurus*, and *Ararat*.

The Himmaleh separate Hindostan from Tartary and Thibet. They extend in a south-easterly direction, about 700 miles towards the borders of China.

These are the highest mountains on the globe, one of their summits being 28,000 feet, or more than five miles, above the level of the sea.

The Altaian Mountains rise near the borders of Kamtschatka, on the north, and under various names, run nearly the whole length of the Russian empire.

A branch which runs into Chinese Tartary is called Bogdo, or the Great Altaian Mountains; and another branch north of this, leading towards Independent Tartary, is called the Little Altaian chain. The same range on the north-west of the Sea of Okotsk, is called the Stannovoy Mountains.

The Ural Mountains, which are situated partly in Asia, and partly in Europe, have been already described.

Mount Caucasus, or the *Caucasian range*, runs from the Black Sea, to the mouth of the river Kur, in the Caspian Sea.

The tops of these mountains are always covered with snow, while the valleys which they form are among the most fruitful on the earth. They are said to be inhabited by seven different nations, or tribes, each speaking a different language.

What are the principal mountains of Asia? What countries do the Himmaleh range separate? How long is this range? What is the elevation of these mountains? Where do the Altaian mountains rise? What are the several branches of this range called? Where does mount Caucasus begin and terminate? What is said of these mountains?

Mount Taurus, or the *Taurian chain*, begins at the Grecian Archipelago, east of Rhodes, and extends into Armenia. These mountains are lofty, rugged, and to a considerable extent covered with pine forests.

Branches of them extend over a great portion of Asia Minor. They give rise to the rivers Tigris and Euphrates.

Mount Lebanon is a branch of the Taurus, which passes along the coast of the Mediterranean, through Syria. Its summits are often clad with snow.

Mount Ararat, in Armenia, is considered a branch of Caucasus.

It presents two insulated summits, the highest of which is perpetually covered with snow, being at an elevation of 9500 feet.

Mount Ida.—This mountain is situated on the coast of the Ægean Sea, in Asiatic Turkey. Ida is also the name of a celebrated mountain on the island of Candia, where the ancients supposed Jupiter was brought up.

The Gauts, or *Ghauts*, are a chain, or chains of mountains in Hindostan. The name signifies a "gate," or "pass," probably because they are separate.

The Ghauts begin at Cape Comorin, and form two branches, one running to the east, and the other to the west of north. The eastern range extends about 70 miles west of Madras, and forms the boundaries of the Carnatic, after which it divides into several small ranges, being separated by valleys covered with thick forests.

The western chain extends along the west coast to the distance of 70 miles, and acquires an elevation of 3000 or 4000 feet, being the highest part of these mountains. This chain passes near to Goa, and enters the Mahratta country, where it divides into several branches.

Where is Mount Taurus? To what rivers does Mount Taurus give rise? Give an account of Mount Lebanon? Where is Mount Ararat, and what is its height? Where is Mount Ida? What are the Ghauts? Where are the Ghauts, and in what direction do they run?

The Ghauts in many places present mural precipices of great height, and their valleys and narrow passes are subject to dangerous inundations from mountain torrents.

These mountains are exceedingly difficult of access, and are crossed only in a few places. The eastern range has only two crossing places for carriages; and through the western, the passes are fifty, or sixty miles in length, and most of them dangerous, except at particular seasons of the year.

MOUNTAINS OF AFRICA.

Africa presents very few high mountains, if we compare the number with that of the other three quarters of the globe. Africa proper, does not contain a single burning mountain, the only one included within its limits, being that of Teneriffe, one of the Canary Islands.

The principal mountains in this quarter of the globe, are the *Mountains of the Moon*, *Mount Atlas*, the *Mountains of Kong*, and those of *Abyssinia*.

The Mountains of the Moon, are the central elevations of the continent, and across which they extend, between the latitudes of 7° and 11°, north. They, therefore, divide Africa into two parts, called North and South Africa. It is from these mountains that the river Nile has its remotest source.

The Atlas Chain, extends east from the coast of the Atlantic to the borders of Egypt, nearly 2000 miles. It separates Barbary from Biledulgerid, and the great desert of Sahara. Of this chain, the most elevated points, are 13,000 feet high, and their summits in that tropical region, are covered with perpetual snow.

Give some account of the Ghauts. Give some acconnt of the mountains of Africa generally. What are the principal mountains of Africa? Where are the Mountains of the Moon? How do they divide Africa? What countries do the Atlas chain separa e? How high are the most elevated points of the Atlas chain? What is said of the little Atlas?

A chain called the *Little Atlas*, extends from the straits of Gibraltar, to Bona, in the State of Algiers.

These mountains yield silver, iron, lead, and antimony in their different parts; and send down innumerable streams of water, which, however, are either soon discharged into the ocean, or lost in the sandy plains, leaving large portions of that parched country with little vegetation.

The Mountains of Kong, are a part of the grand chain of the Mountains of the Moon. These mountains pass through the kingdom of Kong, in Central Africa, and separate this kingdom from the borders of Guinea.

A great proportion of the *gold dust*, or small particles of gold brought from Africa, is said to be washed down from these mountains.

The Mountains of the Moon, give rise to the river Nile, while the Kong is the source of the Niger, the Senegal, and the Gambia.

The Abyssinian Mountains stretch along the coast of the Red Sea, and shut in that kingdom, in the direction of south, and east, so as to deprive her almost entirely of maratime intercourse.

These mountains are supposed in some parts to rise to the elevation of about 13,000 feet, though their altitudes have never been accurately measured.

The Snowy Mountains rise in South Africa, to the height of 10,000 feet, their highest summits being covered with perpetual snow. Of this range, little is known.

Table Mountain.—This celebrated mountain consists of enormous masses of naked rock, rising precipitously to the height of 3,500 feet, near the extremity of the

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Where are the Mountains of Kong, and what countries do they separate? To what rivers do the Mountains of the Moon and Kong give rise? Where are the Mountains of Abyssinia? Where are the Snowy mountains, and what are their heights? Give a description of the Table mountain.

Cape of Good Hope, and at a short distance behind Cape Town. It is two miles in length, and almost every where presents the most frightful precipices.

Mountains of Madagascar.—Besides the mountains of continental Africa, there is a range of considerable elevation running the whole length of the Island of Madagascar. The highest points of this chain, are about 10,000 feet, and many parts are said to be piled up into the most romantic and frightful precipices.

Why high Mountains send down torrents in warm weather.

The above are the principal mountains on the earth, and it is from these, that the great rivers have their sources. Those which are covered with snow during the whole year, often send down rapid and overwhelming torrents, in the dryest seasons, by the melting of the ice, and by condensing the moisture of the higher atmosphere by their coldness.

If a tumbler of cold water be exposed to the air in the summer, the glass on the outside, is soon covered with dew, which it receives by condensation from the air, precisely on the same principle that the steam of an engine, is condensed, and turned into liquid by the effusion of cold water. If the tumbler be supplied with ice, so as to keep it cold, the water thus condensed will fall from its outside in drops, while the ice itself will be melted, or turned into water.

Now, it is plain, that the tumbler only enables us to observe the process, and that the moisture is collected on the ice itself, as well as on the glass, though in the former case we cannot detect the process, because the condensation unites with the water which the ice is forming.

If, however, a piece of ice be carefully weighed, and

What is said of the mountains of Madagascar? Why do mountains covered with ice send down torrents in the hot season? How is this principle illustrated by a tumbler of cold water? How may it be proved that ice condenses moisture from the atmosphere in warm weather?

then exposed to the atmosphere on a summer's day, the water formed will be found to weigh more than the ice, for the reason just explained.

This law applies equally to a mountain covered with snow, and a small piece of ice; for whenever the atmosphere is warmer than the ice, that is, whenever the temperature is higher than 32°, water is condensed from the air, until the ice is entirely melted.

It must not be understood, however, that the ice of a mountain collects moisture in the same proportion that it would do, if situated near the surface of the sea in the hot season, for the atmosphere at the altitude of perpetual congelation, being much less dense than at the surface, holds less moisture in solution, and besides, as the air retains moisture in some proportion to its temperature, that at the elevation of perpetual frost, it is obvious, would contain less in the warm season, than at the surface of the earth.

Still on all mountains, elevated nearly to the regions of perpetual frost, and situated within the tropical, or temperate zones, there is a deposition of moisture from the above cause, during the hot season, for then the temperature of the air becomes greater than that of the ice, and thus while the ice is melting, the quantity of water is increased by the deposited moisture of the atmosphere.

It is often the case also, that a current of warm air rising up from below, is suddenly cooled by the mountain, and deposites its moisture in the form of a torrent of rain, which melting the ice, causes a still greater quantity of water to flow into the plains below. It is from these causes, that Switzerland, and other mountainous countries are subject to sudden, and often exceedingly destructive inundations.

Why does not the ice of a mountain collect moisture at the same rate it would, if situated on the level of the sea? When is there a deposition of moisture on mountains covered with ice? What is the effect when a current of hot air rises to the frozen regions of a mountain? What is the origin of rivers?

RIVERS.

The effusion of springs, and the melting of snow in mountains and elevated lands, cause *streams*, or *brooks*, which flowing into little channels form *rivulets*. These following the declivities of the mountain, unite in the lowest basin. or channel, and form *rivers* of greater or less magnitude, which continuing their course, fall into the sea.

It is evident that, were the earth a continued level, no rivers, brooks, or streams would exist. We see this exemplified in level plains every where. In the great prairies of the West, and in the plains of Africa, and Egypt, no brooks are known, the only streams being rivers which descend from the distant mountains.

As it is the property of all fluids to seek the lowest level, those streams are commonly the most rapid, which descend along the greatest declivities. Hence rapid streams generally have their sources in the most elevated, and precipitous mountains.

It has been observed by some writers, that the extent, and size of a river is in proportion to the extent, and elevation of the mountain range in which it has its source; the Ganges descending from the Himmaleh mountains, and the Amazon from those of South America, are examples.

The size of the river does not however always depend on this circumstance, but more invariably on the extent of the basin through which it passes, and, therefore, on the tributary streams by which it is joined. Thus the Mississippi, which through the Missouri, has its source in the Rocky Mountains, does not depend for its extent, and size, on its high and extensive source, but on the tributaries which join it from the right and left as it flows along its immense valley.

Were the earth a continued level, what would be the effect in respect of brooks, and rivers? What rivers are most rapid? Does the extent and size of a river depend entirely on that of the range of mountains from which it descends? On what position of the earth do the sizes of rivers depend?

The vast size of the rivers of South America, besides the elevation of the mountains from which some of them flow, are more or less dependent on the same circumstance.

The position of the Andes running along as they do, on the western side of that great continent, leaves a vast inclined plane facing towards the east, and hence the waters flowing from that source, having such an immense space to traverse, are swelled to the most majestic volume before they reach the Atlantic, into which they are discharged.

On the contrary, the rivers which flow from the east side of the Andes into the Pacific ocean, are comparatively of diminutive size, since their courses are only two or three hundred miles from their sources, to the ocean into which they flow.

The relative positions of the mountains, plains, and oceans of the Old World, differ very materially from those of the American Continent, in respect to affording great accumulations of water in the form of rivers.

Europe is not of sufficient extent, to afford a single great river, and were its surface two or three times as extensive as it is, still it is so interspersed with seas, bays, and straits, that its waters even then, would find an outlet into the sea, before they accumulated into rivers of the first magnitude.

Africa, although it presents a great surface, is oppressed by a scorching climate, and abounds with sandy deserts, which absorb a large proportion of the waters, flowing from the mountains.

In many instances, streams, which flow constantly from the mountains of Africa, and which in other countries would form rivers of very considerable extent, in this, are drank up by the sands, and evaporated by the heat, so that after running a short course, they entirely disappear, and never reach the ocean.

By what examples is this illustrated? What is said of the positions of mountains, plains and oceans in the old world, in respect to large accumulations of water?

Asia presents also a vast surface of land unbroken by oceanic seas, and bays, but the great Altaian range of mountains divides it into two sections from the north-east to the south-west, and consequently its streams, instead of uniting to form rivers of great magnitude, are divided, and taking opposite courses fall into the Arctic and Indian oceans.

Asia also contains many inland seas, or large lakes which are the final receptacles of the streams that fall into them.

These are the physical causes which present themselves as reasons why the Old World does not contain such magnificent rivers as the *Amazon*, the *Missouri* and the *Mississippi* of the New.

The flowing of Rivers.—Water, by flowing down a declivity receives such an impulse, that the pressure of the particles from behind, upon those before, is sufficient to keep the stream in motion, even when there is no longer a descent in the ground.

Hence a river, in passing along a dead level, has its motion retarded by the friction of the water upon the bottom, but the current is still kept up by the pressure of that which constantly flows down the declivity.

The rate of motion in a river, does not depend on its declivity alone, but on this, and the quantity of water which is thrown into its basin. This is apparent from the circumstance that when a river is low, or the quantity of its water small, its motion may be only just perceptible, while the current of the same stream during a freshet, is at the rate of ten, or twelve miles in an hour.

The declivity required for a given rate of motion in a river is much less than is commonly supposed. So far as we know, however, the relation between the decliv-

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Why does not Europe present great rivers like those of America? How are the comparative smallness of the rivers of Africa accounted for? What is said of the magnitude of the rivers of Asia? Why does a river continue to flow where there is no declivity in the ground? Does the rate of motion in a river, depend on its declivity, or its quantity of water, or both?

ity and the rate of motion has not been precisely determined. This, indeed, from what we have just said, would be a difficult problem, since the motion on the same declivity depends on the quantity of water.

That the descent required to keep water in motion, is very small, without reference to the force given it by passing a rapid, is proved by experiment, and by the known slight variation of the beds of several rivers from a level, as mathematically determined.

Thus the Amazon has a descent of only 10½ feet for the distance of 600 miles, which is but the $\frac{1}{37}$ part of an inch, in the average distance of 1000 feet. The river Loire, in France, falls, in one part of its course, at the rate of one foot in 7,500, and in another, only one foot in 13,500 feet, or more than four and a half miles.

When the fall amounts to, from two to four feet in a mile, the stream becomes a *rapid*, and is navigated with difficulty, even with small boats.

The most rapid rivers in Europe, are the Rhone, and the Inn, and in America the Platte, and the Missouri.

The medium rate at which rivers flow, is from three to six miles in an hour. Few rivers have a velocity, for any considerable part of their course, of more than six miles, while the most sluggish advance at the rate of two or three miles an hour.

Inundations of Rivers.—Nearly, or quite all rivers, are subject to periodical inundations, which are occasioned either by rains, or the melting of snow at certain seasons of the year.

These inundations in the same hemisphere, occur at nearly the same seasons. An allowance, however, must be made, for the greatest height at any particular place, for the distance of the mountain, where the rain or melting snow causes the flood.

Thus the inundations of the Nile, do not take place in Egypt, until the rains in the mountains of Abys-

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What is said of the declivity necessary to give motion to water? What is the rate of descent in the Amazon? At what rate does the Loire fall in different parts of its course? What must be the declivity to produce a rapid? What are the most rapid streams in Europe and America?

sinia, by which they are caused, have nearly, or quite ceased.

FALLS AND CATARACTS.

But all rivers do not always descend from their sources to their mouths, on an inclined plane. They sometimes precipitate their waters down abrupt declivities, or over perpendicular precipices, in which cases they form *falls* or *cataracts*.

These descents generally occur in situations where nature exhibits herself in scenes of the greatest sublimity and grandeur, and hence cataracts have always been esteemed among the most interesting objects of natural scenery.

Cataract of Niagara.—The cataract of Niagara presents the most magnificent spectacle of this kind, in the world; not however, in consequence of the height from which the water falls, but from its vast quantity, the entireness of the stream, and the perpetual thunder which it causes.

This cataract is situated between Lake Erie above, and Lake Ontario below. The distance between the nearest shores of these lakes is 37 miles, and the height of Erie above Ontario, is 322 feet.

The fall of the water on the declivity from Erie to Niagara is 61 feet; the perpendicular fall at Niagara is 150 feet; and the gradual descent from this to Ontario is 106 feet.

The width of the cataract at Niagara is about 3,500 feet, or nearly three quarters of a mile, and its perpendicular descent, as stated above, 150 feet. This immense body of water from its weight, and the velocity of its fall, produces a perpetual trembling in the ground in the neighborhood, and is heard to the distance of 15 or 20 miles in all directions.

What is the medium rate at which rivers flow? In what natural situations are cataracts usually found? In what respects is the cataract of Niagara, the most magnificent in the world? Where is this cataract situated?

Cataract of Tequendama.—The cataract of Tequendama, formed by the river De Bogota, in South America, is by no means an insignificant water fall, even when compared with that of Niagara.

According to Humboldt, the river at a short distance above this fall, is 150 feet wide, but immediately before its descent, it is contracted to the width of 40 feet, when it passes a double bound to the perpendicular depth of 574 feet.

The roar of this fall is heard to a great distance, and the spray below the second bound, produces a most astonishing, and beautiful spectacle.

Cascade of the River Ache.—The fall of the little river Ache, which rises from a glacier on Mount Taurens, in the kingdom of Bavaria, is the highest which has been described. The water is precipitated over a mass of rocks 2000 feet in height, making in its descent, five distinct falls, the last of which, forms a magnificent arch of water, and is dissolved into spray before it reaches the ground.

The noise of the rushing water is heard to the distance of several miles; and the current of air which is set in motion by the last fall is so strong as to force those back who attempt to approach it.

Cataract of the River Lulea.—The greatest waterfall in Europe, is that of Lulea, in Sweden. The river is more than 600 feet broad at the fall, and is precipitated down a perpendicular height of 400 feet.

Cataract of the Missouri.—The Missouri at the distance of 500, or 600 miles from its source, and where its breadth is about 1000 feet, forms several cataracts, which for grandeur and effect, are scarcely excelled, except by the falls of Niagara.

The rapids extend to the distance of 18 miles, and the whole descent in this distance is 360 feet. There are,

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What is the distance of these lakes from each other? What is the height of Erie above Ontario? What is the width, and what is the perpendicular descent of the cataract of Niagara?

forming portions of this descent, three several cataracts, one of which is 80, another 47, and the third 26 feet in height.

Cataract of Montmorenci.—The river Montmorenci, at the distance of nine miles below Quebec, in Canada, forms a cataract 200 feet in height. The breadth of the river at the fall, is about 50 feet, but the quantity is small, and chiefly converted into spray before it reaches the ground. The effect, however, is beautiful from the snowy whiteness of the spray, and the cloud of vapor which is constantly rising from it.

Cataract of the Passaic.—Few natural scenes in the United States, are more celebrated than the Falls of Passaic. The Passaic is a small river in New Jersey, and the falls are at Patterson, about 15 miles from Newark.

The river is 120 feet wide, and is precipitated in one entire sheet, from the elevation of 70 feet.

Fall of the Rhine.—The fall of the Rhine at Schaffhausen, has been celebrated from time immemorial, and every year attracts thousands of travellers to behold its phenomena.

The river at the cataract, is 450 feet wide, and before it reaches the fall, has gained the most impetuous velocity, by passing over a succession of declivities.

"Gradually acquiring strength with its speed, and descending at first in a broad verdant sheet, till whitening by degrees into foaming impetuosity, it bursts at last in three distinct branches, over a precipice, upwards of eighty feet in height, and presents the most sublime spectacle in Switzerland."

It appears from the geological features of the country above this fall, that the valley through which the Rhine now passes, was once a great lake, and that its waters were drained by the disruption of the rocks now forming the cataract.

Cataract of Reichenbach.—The cataracts of the Alps,

of which there are several, are among what may be called the "tremendous" features of that romantic country. Among these falls, that just named, is among the most celebrated, and is given as an example of that "wild magnificence" which so often presents itself to the astonished eye of the Alpine traveller.

This cataract is formed by the union of several small streams into a considerable river, which rushes over a precipice at the elevation of 500 feet above the gorge into which it falls.

There is, however, a projecting rock which breaks the sheet at the distance of about 100 feet below the first, or upper fall, after which it descends 400 feet, by a single bound, with a breadth of 30 feet.

Says Dr. Beattie, in his "Switzerland Illustrated," when describing this scene.—"Around the shattered precipices—

> Trees and shrubs, in wild disorder,
> Fringe the gulf's horrific border;
> While ceaseless from the dread profound;
> Breezes waft the dismal sound."

From a certain position, "the fall," continues this able writer, "is observed in all its stages, from the wave-worn precipice, where it makes its first trial of strength, to the next appalling shock where the wide volume is dissipated in snow and spray—crushing the rock in its descent,—filling the ear with the roar of its agony, and the mind with images of horror and destruction. It is at this point, that all who would *feel*, as well as contemplate the sublimity of the scene, should take their stand; and—

> There watch "the hell of waters" under—
> Swift as light, and loud as thunder."

Fall of Bohren.—It was near this horrid place, that the following incident happened, which we relate as an example of the every day dangers, to which the inhabitants of these Alpine regions are beset.

Christopher Bohren, an inn-keeper, having occasion to cross the glacier between the Wetterhorn, and Met-

tenberg, was considerably advanced on his way, when the ice beneath him suddenly breaking, he was plunged to the depth of 64 feet into a chasm. With his arm broken, and his wrist dislocated by the fall, he had still sufficient presence of mind to make some exertions for his preservation. Stunned, and half frozen, he groped about him, and in the bottom of his icy prison, discovered a tunnel through which the melted waters of the glacier had forced an outlet. Insinuating himself into this canal, he advanced painfully, despairing at every motion, of ever again beholding the light. The warmth of life was fast yielding to the deadly chill of the cavern, in which, to all appearance, he was doomed to perish. Every step he advanced on his knees, and *elbow*, (for of the latter he had only one left,) threw a keener pang into his heart, and the mingled gurgling, rushing, and tinkling, of the deeply channeled waters, sounded in his ear a horrid dirge, that announced his wife a widow, and his children fatherless.

This very thought, was however, probably the cause of his redoubled exertions, and which made the agony of fear the beginning of hope; for when he had crawled along the icy current for about 60 feet, he suddenly emerged into the light of day. The torrent had there its issue; and the captive, following its direction, was speedily restored to his wife, and the world, and lived many years afterwards, to narrate his miraculous escape.

QUANTITY OF WATER WHICH RIVERS DISCHARGE INTO THE SEA.

From observations made on the quantity of rain which falls in different parts of the world, it has been estimated that the mean annual amount on the globe, is about three feet in depth. This quantity, is equal to no less than 16,000,000,000,000,000 cubic feet of water, which falls on the earth every year, including sea, and land.

Now, if we suppose that a third part of this falls upon the land, we should then have more than 5,000,000,000,-

000,000 cubic feet for the supply of rivers, and the economy of vegetation.

To compare this, with the quantity of water discharged by all the known rivers in the world, we will take with Buffon, the example of the Po, of Italy. This river, according to Riccioli, before it divides into branches, has a mean breadth of 1000 feet, and a depth of 10 feet, with a velocity of 4 miles an hour. The quantity of water discharged, as estimated from these data is about 5,000,000,000 cubic feet per day, or nearly 2,000,000,000,000 cubic feet, annually.

Now, to continue the calculation, if we suppose a fifth part of the water, which descends in rain upon the land, to be dissipated by evaporation, and another fifth to be decomposed by the process of vegetation, we should still have remaining, as much water, of that which falls in rain upon the land as would be discharged into the sea, by 1500 such rivers as the Po.

To take another view of the subject; the Po traverses a country about 380 miles in length, and the rivers which flow into it on each side, arise from sources which are about sixty miles distant from the main stream. This gives about 45,600 square miles of country which is drained by the Po.

Now, according to Buffon's estimate, the whole surface of dry land on the earth, is equal to 63,728,933 square miles, and if we suppose each portion of the earth's surface, equal in extent to the basin of the Po, to be drained by a river of the same magnitude, we should have by this computation, about 1400 rivers of the size of the Po, to drain the land of the globe.—(*Ed. Encyclopedia*, Article *Phys. Geography.*)

PRINCIPAL RIVERS ON THE GLOBE.

The limits prescribed to this work, will only allow that we should describe some of the principal rivers in each quarter of the globe.

RIVERS OF SOUTH AMERICA.

The principal rivers of South America, are the *Amazon*, the *Oronoco*, and the *La Plata*.

Amazon.—The sources of this river, the largest in the world, are in the Andes, near the shores of the Pacific ocean. Its course is towards the east, and its discharge is into the Atlantic ocean under the equinoctial line. Length, 4000 miles. Width of its mouth, 150 miles. Depth at 1500 miles from its mouth, 90 feet. Receives in its course about 200 rivers, several of which are not inferior to the Danube, or Nile. Boat navigation, 3000 miles.

Oronoco.—Source, in the north of the middle range of the Andes, in north latitude, 5°. Course, east, turning to the north, and then again to the east. Mouth in the Atlantic, opposite the Island of Trinidad. It has several mouths, the widest of which, is 25 miles. Length, 1400 miles. The quantity of water discharged by this river, is probably little, if any, inferior to that discharged by the Ganges. Navigable, about 700 miles.

La Plata.—Source, in the mountains of Peru, in the centre of the continent. Course, south for more than 1500 miles, and then turning to the east, discharges into the Atlantic, in about latitude 35° south. Mouth, 150 miles wide. Navigable for ships, 1000 miles to Assumption, and for boats, 800 miles higher. Length, 2000 miles. The La Plata, is formed chiefly by the rivers Paraguay, Parana, and Uraguay. The main branch takes the name of Paraguay, in its passage along the borders of that country.

What are the principal rivers of South America? Where are the sources of the Amazon? In what direction is its course? Where is its mouth? What is its length? What is the breadth of its mouth? Where is the source of the Oronoco? What is its course? Where is its mouth? What is its length? How far navigable? Whence does the La Plata rise? Its course? Where is its mouth, and how wide? How far navigable? What is its length?

There are many rivers on the west side of the Andes, which run into the Pacific ocean, but they are generally of diminutive size, and the geography of few of them are correctly known.

RIVERS OF NORTH AMERICA.

The rivers of North America, are second in size, and extent to none on the globe, except those of South America.

The principal rivers of North America, are the *Mississippi*, *Missouri*, *Arkansas*, *Platte*, *White River*, *Red River*, *Kansas*, *Tennessee*, *Yellowstone*, *Ohio*, *Columbia*, *Cumberland*, *Wabash*, *Lewis' River*, *Clarke's River*, and the *Multnoma*.

These are from 800, to 3000 miles in length, besides which, there are in the United States, more than twenty rivers, from about 200, to 700 miles in length, which enter the Atlantic, and probably two or three times this number, of similar sizes, which fall into the Pacific, Mississippi, and other receptacles.

Mississippi.—Source, in the highlands of the 47th and 48th degrees of north latitude. Course, south, often making large sweeps east and west. Length, 3000 miles. Navigable to the Falls of St. Anthony, about 2000 miles for boats of 30 tons, and to Natchez, 300 miles from its mouth, by ships. Discharges into the Gulf of Mexico, below New Orleans, by several mouths.

Missouri.—Source in the Rocky Mountains, about 15 degrees of longitude west of the source of the Mississippi, and under the same parallels of latitude. Course, first east, then making a sudden turn, its course with various windings, is south-east, until after running 2500 miles, it falls into the Mississippi, above St. Louis.

What are the principal rivers of North America? What are the lengths of these rivers? What number of considerable rivers besides these, are there in the United States? Where is the source of the Mississippi? What is its length? How far navigable, &c.? The same questions may be asked with respect to the other rivers.

The latter river, at the point of junction, is a mile and a half wide, and the Missouri, half a mile wide. The union takes place about 1000 miles from the mouth of the Mississippi. The Missouri from its source to the Gulf of Mexico, has a length of 3500 miles.

Arkansas.—Source, in the Rocky Mountains, between the 35th and 40th degrees of north latitude. Course, south-east. Length, 1500 miles. Falls into the Mississippi. Navigable, during the spring freshets for boats, nearly to its source.

Platte River.—Source, in the Rocky Mountains. Course, east. Length, 1000 miles. Falls into the Missouri below Council Bluffs.

White River.—Source, among the Black Mountains, in Arkansas. Course, east, then south. Length, 1300 miles. Falls into the Mississippi a little above the mouth of the Arkansas. Navigable for boats 1200 miles, but its course is so circuitous, that this distance is no more than 500 miles in a direct line. Its mouth is 300 yards wide.

Red River.—Source, in the highlands of New Mexico. Course, east, then south-east; passes through Louisiana, and falls into the Mississippi, about 240 miles above New Orleans. Length, 1500 miles. This river is blocked up by an immense raft of timber, which extends 60, or 70 miles, above which it is navigable at most seasons of the year, to the extent of 1000 miles.

Kansas River.—Source, in the Great American Desert, between the sources of the Platte, and the Arkansas. Course, east, inclining to north. Length, 1200 miles. Falls into the Missouri at the western boundary of that State. Navigable for boats, nearly 1000 miles.

Where is the source of the Red River? What is its direction? What is its length? Where does it join the Mississippi? How is the navigation of this river prevented? The same questions may be asked with respect to the other rivers.

Yellowstone.—Source, in the Rocky Mountains. Course, north-east; passes through the western part of the State of Missouri, beyond the Black Hills, and falls into the Missouri river, by a mouth 300 yards wide, and 1400 miles above the mouth of that river. It is a broad, deep, and majestic stream, and is navigable many hundred miles. Length, 1000 miles.

Osage.—Source, in the highlands, between the sources of the Arkansas, and Kansas rivers. Direction, north-easterly; joins the Missouri in the centre of the State of that name. Length, 800 miles. Navigable for boats, 600 miles. The Osage passes through one half of the State of Missouri, and is a large, and very important stream.

All the rivers thus described, fall into the Mississippi from the west, and north, and have their sources either in the Rocky Mountains, or in that vast plane inclining towards the east, the northern portion of which is called the Missouri Territory, and which lies between the Missouri, and the Mississippi rivers.

Besides these, a great number of smaller streams, many of them of the size of the Connecticut, join these rivers in their courses, from the same direction.

From the east, the chief tributaries of the Mississippi, are the *Wisconsin, Illinois, Kaskaskia, Ohio,* and the *Yazoo.*

Wisconsin.—Source, in the North West Territory, south of Lake Superior; passes through the valleys of the Wisconsin Hills, and joins the Mississippi at Prairie du Chein, below Fort Crawford. Length, about 400 miles. Mouth, 800 yards broad. Navigable for boats, several hundred miles.

Illinois.—Source, in Indiana, near the south end of Lake Michigan. Direction, west, then south through

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Where are the sources of all these rivers, and where are their terminations? What rivers are tributary to the Mississippi from the east? Where is the source of the Wisconsin, &c.?

the State to which it gives name, and falls into the Mississippi, with a mouth 400 yards wide above St. Louis. Length, 500 miles. It is a placid, transparent stream, and navigable for boats to a great distance.

Kaskaskia.—Source, in the interior of the eastern part of Illinois. Direction, south-west; passes through the south-eastern half of the State, and joins the Mississippi at the town of Kaskaskia. Length, nearly 300 miles. Navigable for boats, for most of its length, at certain seasons.

Ohio.—Sources, in the Allegany mountains of Virginia, and Pennsylvania, through the Monongahela, and Allegany rivers. Direction, south-west, with many curves, separating the States of Ohio and Virginia, and Indiana and Kentucky. It falls into the Mississippi, between the States of Kentucky and Illinois. Length, 1350 miles. Width, below Pittsburgh, 1000 miles from its mouth, 600 yards. Below Cumberland river, its average width is 1000 yards. Navigable for steam boats to Pittsburgh. The Ohio and its tributaries, are said to afford 5000 miles of boat navigation.

Yazoo.—Source, in the Bluffs of the Chickasaw country, State of Mississippi, and near the limits of Tennessee. Direction, north-west; falls into the Mississippi river, by a mouth 100 yards wide, 12 miles above Walnut Hills. Length, about 250 miles.

These are the principal streams, tributary to the Mississippi from the east, and north. With the exception of the Ohio, they are far inferior to those which join this vast river from the west.

The Ohio, has an immense number of tributary streams, among which, are the Tennessee, 1100 miles long; the Cumberland, 750 miles long, and the Wabash, 500 miles in length.

Rivers Tributary to the Mississippi, with their lengths.

From the West.	Miles in length.	From the East.	Miles in length.
Red River,	1500	Wisconsin,	400
Missouri,	2500	Illinois,	500
Arkansas,	1500	Kaskaskia,	300
Platte,	1000	Ohio,	1350
White River,	1300	Tennessee,	1100
Kansas,	1000	Cumberland,	750
Osage,	800	Wabash,	500
Yellowstone,	1400	Yazoo,	250

Rivers West of the Rocky Mountains.

The chief rivers west of the Rocky Mountains, are the *Columbia*, *Multnoma*, *Lewis' River*, and *Clarke's River*.

Columbia.—Source, in the western declivity of the Rocky Mountains, near the head waters of the Missouri. Direction, north, turning towards the west, and making several great sweeps. It falls into the Pacific ocean by a broad estuary at Cape Disappointment, in north latitude 46° 24′. Navigable for large vessels, 180 miles from its mouth. Length, 1500 miles. This is a noble stream, abounding in salmon, and towards its mouth, with seals.

Multnoma.—Source, in the highlands, west of the Rocky Mountains. Direction, north-west; falls into the Columbia, at about 100 miles from its mouth. Length, 900 miles. This is a large tributary, but has been little explored.

Lewis' River.—Source, in the Rocky Mountains. Direction. The south fork runs nearly north, and the north fork, north-west, and after joining, turns towards the

What are the tributaries of the Mississippi on the west side? What are its tributaries from the east? Give some account of the Columbia river, and its branches?

south-west, and falls into the Columbia, with a mouth 250 yards wide. Length, 900 miles.

Clarke's River.—Source, in the Rocky Mountains, near that of the Missouri. Direction, north, forming a semi-circle towards the south-west, and falling into the Columbia, in about 48° of north latitude. Length, 900 miles.

These rivers have their sources, and terminations, in that vast, and chiefly unexplored country, called Oregon Territory, which lies north, and west of the Rocky Mountains, and between them, and the Pacific ocean.

North American Rivers which flow into the Atlantic.

The principal rivers of North America, which fall into the Atlantic, are the following:

Rivers flowing into the Atlantic.

	Miles in length.		Miles in length.
St. Lawrence,	2,000	Potomac,	620
Penobscot,	250	James,	550
Kennebec,	200	Roanoke,	350
Androscogin,	170	Cape Fear,	350
Saco,	160	Pedee,	450
Merrimac,	200	Santee,	450
Connecticut,	410	Savannah,	700
Hudson,	324	Ogechee,	250
Delaware,	300	Altamaha,	500
Susquehanna,	450	St. John's,	300

Rivers flowing into the Gulf of Mexico.

	Miles in length.		Miles in length.
Apalachicola,	500	Tombigbee,	450
Alabama,	450	Mississippi,	3,000

What are the chief rivers in North America, which flow into the Atlantic? What rivers flow into the Gulf of Mexico?

RIVERS OF EUROPE.

The principal rivers of Europe, are the *Volga, Don, Rhine, Danube, Loire, Dnieper, Rhone, Lena,* and the *Vistula.*

Volga.—Source, in the highlands of Central Russia. It has a circuitous course towards the south, and forms a part of the boundary between Europe and Asia. Length, about 2000 miles. It falls into the Caspian Sea, near Astracan. Navigable, more than 1500 miles. This is the largest river in Europe. By means of a canal, there is a communication between this river, and the Lake Ladoga, the river Neva, and the Baltic Sea.

Don.—Source, in the Lake St. John, in the interior of Russia. Direction, south-east, then turning suddenly to the south-west, is discharged into the Sea of Azoph. Length, 900 miles. The navigation is obstructed by bars, and sand banks, and, except during the flood season, is little employed.

Rhine.—Source, in the mountains of Switzerland, in the Canton of Grisons, about 6000 feet above the level of the sea. It passes through the Lake of Constance, from east to west, and flows west, and forms the celebrated cataract of Shaffhausen; after which, it continues west to Basle; then turns north, and passes through the Netherlands into Zayder Zee, an arm of the North Sea. Length, 700 miles. This river is subject to high floods, but is navigable below Basle for vessels of considerable burthens. The cities of Cologne, in Germany, and Strasburg in France, stand on the Rhine.

Danube.—Source, in Baden, Germany, in latitude 48°. Course, north, winding towards the east to Ratis-

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What are the principal rivers of Europe? Where is the source of the Volga? Give an account of this river. Give an account of the Don. Give an account of the Rhine.

bon, and passing Vienna in Austria, afterwards runs to the south, and still changing its course by many turns, proceeds easterly, and by several mouths, falls into the Black Sea. In its course, it receives the Drave, Save, and many other tributaries. Length, 1600 miles. This noble stream, arising in Germany, passes through Austria, Hungary, and Turkey in Europe. It is navigable for boats, about 1400 miles. Its navigation is free to the city of Ulme, in Wurtemberg.

Loire.—Source, in the department of Ardeche, in France, towards the borders of Switzerland. It runs east, and dividing France nearly into two equal parts, flows into the Atlantic at the Bay of Biscay, through the Strait of Bell Isle. Length, 600 miles. By means of a canal, this river is connected with the Rhone, and thus a navigable communication is formed from the Atlantic to the Mediterranean, through the centre of France.

Dnieper.—Source, in the northern frontier of the government of Smolensk in Russia. It runs south, and making a long sweep towards the west, turns south-east, and flows into the Black Sea, at Cherson. Length, 1000 miles. It is navigable to Smolensk, 800 miles, and by canals, this river is united to another, which falls into the Baltic, and thus a navigable communication is made between the Black Sea, and the waters of Northern Europe, through Russia.

Rhone.—Source, in the mountains of Switzerland, by several streams, one of which comes from a glacier, called the Rhone. Direction, south, through the Lake of Geneva, then west to the city of Lyons, and then continues south to the Gulf of Lyons, in the Mediterranean, where it enters by several mouths. Length, 500 miles. This river is subject to tremendous floods, which by bringing down sediment, has increased its delta in an

Give an account of the source, and direction of the Danube. Give an account of the source, direction, and termination of the Loire. Of the Dnieper. Of the Rhone.

extraordinary manner. This has already been described.

Oder.—The Oder has its source, in the Mountains of Moravia, in the Austrian Empire. Course, north-east, through Brandenburg and Pomerania, into the Baltic Sea, by three channels. Below Stettin, it forms a large bay. Length, 400 miles. It is navigable, about 300 miles.

Vistula.—Source, in the Carpathian Mountains, on the confines of Moravia, and Hungary. It runs east, and turning south, and passing through Poland, and Prussia, by Cracow, and Warsaw, flows into the Baltic by three mouths. Length, 450 miles. Navigable, 400 miles.

RIVERS OF ASIA.

The principal rivers of Asia, are the *Lena*, *Yenisei*, *Indus*, *Amour*, *Hoangho*, *Ganges*, and the *Cambodia*.

Lena.—This river rises in the mountains north-west of the Lake Baikal, in Siberia. Its course is east, then north-west, to the Arctic ocean. It passes through the entire breadth of Siberia, and is said to be five miles broad, several hundred miles from its mouth. Length, 2000 miles. On the bank of this river, was found an elephant preserved in ice, and where it must have remained for thousands of years.

Yenisei.—Source, in the Altaian chain of mountains, which separate Siberia from Chinese Tartary. Course, north, with various windings, to the Arctic ocean, which it enters east of the Gulf of Oby. Length, 2000 miles. It passes through Siberia, dividing it into east, and west portions.

Where is the source of the Vistula, and where its termination? What are the principal rivers of Asia? Give an account of the source, direction, and termination of the Lena, Yenisei, &c.

Indus.—Source, in the mountains of Tartary, belonging to the Himmaleh range. Course, south-west, then turning to the south, it enters Hindostan, near its eastern extremity, and passing through the Province of Sinde, enters the Arabian Sea, by several mouths. Length, 1300 miles. This river affords navigation, for vessels of 200 tons, to the distance of 850 miles. On the east side there is an immense sandy desert, 500 miles long, and 60 broad.

Amour.—Source, in the Yablonoi mountains, a part of the Altaian chain. Direction, south-east, forming a part of the boundary between Siberia, and Eastern Tartary. It then wanders towards the east, and falls into the Sea of Okotsk, opposite the Peninsula of Kamtschatka, in north latitude, about 55°. Length, about 2000 miles.

Hoangho.—This is usually called the *Yellow* river, from the quantity of clay which it brings down. Its source is in the mountains of Chinese Tartary. Course, north-east, then bending south, it enters China, and pursues an easterly direction, until it falls into the Yellow Sea. Length, 2000 miles. At about 70 miles from its mouth, this river is crossed by the Imperial Chinese Canal. Its breadth here, is about one mile, but it is so rapid and shallow, as scarcely to be navigable, except at particular seasons.

Such is the quantity of sediment, in the waters of the Yellow river, that Sir George Staunton estimated that it brought down in a single hour, two millions of cubic feet of earth, or 48,000,000 cubic feet per day. He further estimated, that this quantity would require only 70 days to convert a mile square into firm land, and if the Yellow Sea, be taken at 120 feet deep, and its area 125,000 miles, the whole would be turned into terra firma, in 24,000 years.

Ganges.—This celebrated river of Asia, has its source

What is said of the quantity of sediment in the Yellow river?

in the Himmaleh Mountains, and running south-east, traverses a great proportion of the northern provinces of Hindostan. In its course, it receives the Jumna, 800 miles long, and several other rivers from the east. Near its influx, it receives the Burampooter, 1500 miles long, from the north, and then flows into the Bay of Bengal, by two principal channels. Length, 1600 miles. Navigable, 1350 miles, from its mouth to its passage through the lower range of the mountain. At the distance of 800 miles from the sea, it is, when lowest, about 30 feet deep. This river, and its branches, reach the very interior of India, and by which, vast quantities of goods are transported; there being, it is said, no less than 30,000 boatmen employed in its navigation.

Cambodia.—This river, has its source in the Mountains of Chinese Tartary, and running south-east passes through Thibet, a part of China, and through the Kingdom of Cambodia, into the Chinese Sea, east of the Gulf of Siam. This river, as it passes through China, is called *Kiou Long*. At 250 miles from its mouth, it divides into two great branches, the eastern of which, is called the *Japanese* river. Length, 2000 miles. It is a noble stream, and navigable to a great extent.

RIVERS OF AFRICA.

The principal rivers in Africa, are the *Nile*, *Niger*, *Senegal*, and the *Gambia*.

Nile.—This river, has its source in the Mountains of the Moon, and receives streams from those of Abyssinia. It passes north through Sennaar, and then turning west to Dongola, turns again to the north-west, and runs through the Great Desert of Nubia, into the plains of Egypt, where, at Cairo, it divides into two branches, forming the delta of the Nile, and thus enters the head

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Give an account of the source, &c. of the Ganges. The same of Cambodia. What are the principal rivers of Africa? Where is the source of the Nile?

of the Mediterranean, near Alexandria. The ancients reckoned and named, eleven mouths of the Nile, but at present, only two, Rosetta, and Damietta, are navigable. Length, 2000 miles. The navigation for boats, extends to the cataracts of Nubia, about 600 miles from its mouth. The Delta has many shallow lakes which communicate with the sea; these are connected with the two arms of the river, by canals.

Niger.—Source, in the northern declivity of the Kong mountains. Direction, first north-east, then running east, it pursues a southerly course to the sea. It passes by the cities of Tombuctoo, Boursa, Rabba, and Egga, and enters the Atlantic, in about 5° north latitude. The Niger, is probably about 2000 miles long. No subject of Physical Geography, has excited more attention, and interest, than to determine the source and termination of this river.

Some writers believed that it was dried up by a great desert, and never reached the sea, while others supposed that it fell into the river Congo, and thus found the ocean. Before the travels of Mungo Park, it was even disputed whether it flowed towards the east, or west. In this state of uncertainty, the British government dispatched an expedition expressly to ascertain, by proceeding up the Congo, whether the Niger could be found in that direction. Still, nothing certain on the subject, was known, until the two Landers, Richard and John, in 1830, solved this grand geographical problem, by tracing the river to its mouth, and finding its course to be south-east, and that, like other rivers, it runs into the sea. It discharges its waters by several channels, like most other great rivers of the old world, and forms a delta along the coast, 240 miles in extent.

Senegal.—This river rises in the Kong mountains, in Negroland, and flows west on the southern confines of the great Desert of Zahara, and enters the Atlantic

What is its length? Niger. Its length, &c. Senegal. Its source, and length, &c.

ocean, about 120 miles north-east of Cape de Verd, and opposite to the cluster of islands of this name. Its course is flexuous, until it arrives to within a few miles of the sea, when it turns to the south, and runs 75 miles along the coast, and then passes into the ocean, by a mouth, a mile and a half in width. Its navigation is prevented by sand bars.

Gambia.—Source, in the north-west portion of the Kong mountains. Runs west, and after various windings, falls into the Atlantic, about 150 miles south of Cape de Verd, about in latitude 13° north. Length, 600 miles. Navigable, 400 miles from its mouth, when it is impeded by falls. It has several mouths, forming a broad delta.

Summary concerning Rivers.

1. In general, when a tributary falls into a large river, the width of the main stream is not thereby increased. Thus, at the place of union between the Missouri, and the Mississippi, the quantity of water in the former, is fully equal to that of the latter, and yet the Mississippi is wider above, than below the junction. The latter river is, however, said to be deeper below, than above, the mouth of the Missouri. In general, the effect of the tributary, is to increase the velocity of the main stream, but not its width.

2. All great rivers have their sources in mountainous countries.

3. The formation of deltas so common to nearly all the rivers in the old world, are very rare appendages to those of the new. The deltas of the Nile, the Ganges, the Rhone, the Senegal, and the Indus, as well as many others in the ancient world, have been mentioned, and

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Why is not the width of a river increased by a tributary? Where do all great rivers have their sources? What is said of the formation of deltas by rivers of the old and new world? What is the estimated mean velocity of rivers?

several of them described as the means by which considerable changes have been wrought on the surface of the globe. These rivers unite with the ocean by at least two, and some of them by many channels. But the rivers of America, with an exception, or two, all discharge their waters by a single channel. The Mississippi, we believe, is the only river on this side of the Atlantic, which has formed a delta of any magnitude. This difference must be accounted for by the position of the adjacent coasts, and the depth of the water, beyond it, where the discharge is into the ocean. But many of our large rivers unite with the Mississippi where their sediment is carried away by the main stream.

4. The mean velocity of rivers has been estimated at six miles per hour. But it is obvious, as nearly all streams are subject to periodical floods, there must be a great difference in this respect, at different seasons of the year.

5. Rivers sometimes disappear, to the astonishment of the inhabitants on their banks. In 1752, the entire bed of the Rio del Norte, a considerable river in North America, suddenly became dry for the extent of 180 miles. But after an absence of several weeks, it again reappeared as usual. This mystery was solved by finding that the waters had descended into a newly formed chasm, and ascended by another; having followed its subterranean channel, until that was filled up by rocks and sediment; when it again assumed its old bed along the surface.

Humboldt relates a similar case, which occurred to the river Amazon, about the beginning of the eighteenth century. At the village of Puyaya, the people saw, with terror and astonishment, that the bed of that vast river was left naked, its waters having disappeared for several hours. This surprising phenomenon was caused by the fall of a mountain across the stream at the cataract of Rentena, in consequence of an earthquake.

6. Many rivers are peculiar for their colors. The

Yellow river, in China, has its name from the color of its waters, being tinged with yellow clay. The Danube retains a yellow hue throughout the year. The Rhone, after leaving the Lake of Geneva, has a color decidedly blue, which is attributed to its purity, having deposited all its sediment in its passage through the lake.

Humboldt distinguishes the waters of tropical rivers, by the epithets, *white*, and *black;* and informs us that the black waters are the purest and most limpid, such being their transparency, that the smallest fish are visible in them to the depth of 20, or 30 feet.

The coloring principle in these waters, is supposed to be vegetable extractive matter; but it cannot be detected by analysis. It is not a little remarkable, that both the crocodiles, and musquetoes, the greatest pests of equatorial America, carefully avoid the black waters.

When the smallest breeze plays upon these dark waters, they appear of a fine grass green, like the lakes of Switzerland.

7. Rivers in their junction with the sea, present several phenomena worthy of notice. The currents of great rivers remain fresh, and distinct from the waters of the ocean, often to great distances at sea. The current of the Ganges is plainly visible, and its water fresh, at sixty miles from its mouth.

The opposition which takes place between these river currents, and the tides of the ocean, in some instances, produces surprising effects. Thus, the opposition of the tide to the current of the mighty Amazon, sometimes produces a mountain of water 200 feet high.

LAKES.

Lakes are extensive accumulations of water, surrounded by land.

Lakes may be divided into four classes.

First. Such as have no outlet, and do not receive any running water.

Second. Those which discharge water, but have no perceptible supply.

Third. Those which receive, and discharge water.

Fourth. Those which receive water, but have no visible outlet.

First. *Such as neither receive nor discharge water.*—These are generally small lakes, consisting of aqueous accumulations from the surrounding country. Some of them appear to have been originally the craters of volcanoes, and while the basins of others, have been formed by the sinking of the ground during earthquakes. Many of the latter kind are found in Calabria.

Second. *Those which discharge water, but have no perceptible supply.*—These lakes, which are not uncommon, are fed by springs, which have their sources in the adjoining mountains or hills. Where there happens to be many such springs situated around the basin of the lake, the stream which flows from it, is sometimes very considerable; and some great rivers have their sources in such lakes. They are often situated at great elevations. There is one of this kind on Mount Rotondo, in Corsica, which is more than 9000 feet above the level of the sea.

Third. *Those which both receive, and discharge water.* These are the most common, and are often formed by the expansion of a river. The Lake of Geneva is of this kind, the Rhone, from the neighboring mountains, falling in at one extremity, and passing out at the other.

More commonly, however, these lakes are supplied by numerous small streams, while their superabundant waters are discharged by a single larger one, or sometimes by a river, of greater, or less size.

The immense lakes of North America are of this kind.

How are the four classes of lakes distinguished? How are the first class formed? How are those of the second class supplied?

These are five in number, viz. Superior, Michigan, Huron, Erie, and Ontario. They are all connected together, by streams passing from one to the other. The waters of Superior and Michigan, flow into Lake Huron; those of Huron, into Erie; and those of the last, into Ontario. The greatest cataract in the world, is formed by the passage of the water from Erie into Ontario; and the final exit of the accumulated waters of this vast chain of lakes, is through the river St. Lawrence, into the Atlantic ocean.

Fourth. *Lakes which receive water, but have no visible outlet.*—These lakes often present phenomena, which it is more difficult to explain. The largest, and best known lakes of this class, are, the Caspian Sea, and the Lake Aral, both situated in western Asia.

The Caspian Sea is about 700 miles long, and from 300 to 400 miles wide; and into it are discharged the Volga, the Ural or Yaile, and the Kur rivers, besides many smaller streams. The Volga is 2000 miles in length; and, at certain seasons, brings down vast quantities of water from the mountains of Russia; and yet, this Sea, so plentifully supplied with water, has no visible outlet. Many theories, and conjectures, have been offered, to explain this anomaly; but the process of evaporation, from so great a surface, is perhaps sufficient to account for the phenomenon.

The Lake Aral, is much smaller than the Caspian; but has the same peculiarity, and which must be accounted for in the same way.

There is a current constantly setting into the Straits of Gibraltar, to supply the evaporation from the surface of the Mediterranean.

PERIODICAL LAKES.

These are lakes, which are formed at certain seasons,

Give an account of the third class. What are the lakes mentioned which receive rivers, but discharge no water? How is this phenomenon explained? What rivers does the Caspian receive? What are periodical lakes?

by excessive rains, or by the overflow of rivers; but which again become dry at other seasons. In a few instances, such lakes are formed by the waters of subterranean rivers, which, when their channels are overflown, throw up their waters through caverns, and thus, form for a time, considerable bodies of water.

Lake Cirnitz.—The most celebrated lake of this kind, is that of *Cirnitz*, or *Cirnitzersee*, in Illyria, Austria.

This lake is considered a great curiosity, and has been the subject of dispute among naturalists. The water rushes through several apertures, which are said to be eighteen in number, from a cavern below the crust of the earth. This takes place in the fall of the year, during the rains in the adjacent country, and if the water falls in abundance, the lake is filled the sooner; and, what is most singular, an abundance of fish, some of them of large size, come up with the water, and supply the inhabitants with food.

The lake thus formed, remains during the winter, and subsides again in June, by the same apertures through which its waters came; after which the land affords fine pasturage, or is sown with summer grain. Thus, it is a common saying, that one may sow, reap, fish, and hunt, in the Cirnitz, in the course of the year.

Lakes of the Morea.—Along the coast of the Morea, in Greece, there are many subterranean caverns, which receive the water from the adjacent mountains, and convey it under ground into the sea. In several places, the mouths of these channels open at a distance from the shore, and the fresh water may be seen boiling up from the bottom, sometimes with such force, that, in calm weather, the surface of the sea is perceptibly elevated above them.

In other instances, the water flows down in channels, on the surface, and is absorbed by fissures in the ground, communicating with the cavern below.

But when the quantity of water is greater than the

What is said of the lake Cirnitz?

fissures can absorb, then lakes of various sizes are formed, which remain during the rainy season; after which, the water continuing to descend through the fissures, the whole is drained, and the dry land again appears. Thus do these lakes appear, and disappear, every year.

CLIMATE.

Climate is constituted by the annual temperature, and the changes of weather, at any place.

We have already illustrated by a figure (fig. 5), the divisions of the earth into Zones, called the *Torrid*, *Temperate*, and *Frigid*.

These are artificial divisions, but are supposed to correspond to the temperature, and climate, of each.

Thus the torrid zone, extending to 23½ degrees on each side of the equator, is the warm region of the earth; the zone reaching from this to within 23½ degrees of the poles, is the mild or temperate portion of the earth; while within the polar circles, the cold is excessive, constituting the frigid zones.

We have, however, shown, under the article *Isothermal Lines*, that the actual temperature of two places, is not indicated by a line drawn around any given portion of the earth; or, in other words, that two places situated under the same degree of latitude, may differ much with respect to their mean annual temperatures.

In attempting to account for the causes of this difference, we have shown the influence of the different positions of sea, and land, and of winds, and marine currents, on the temperature of different parts of the earth.

It now remains to give a more general account of the climates, and temperatures, of different parts of the world, preparatory to speaking of the Distribution of Plants, and Animals, in the different regions.

What constitutes climate? On what part of the earth is the torrid zone? Where is the temperate zone, and where the frigid zone?

Causes which influence Climate and Temperature in Various Latitudes.

The annual variation of temperature between the tropics, is very inconsiderable. At St. Helena, as already shown, the difference between the highest, and lowest degrees of heat, during the year, is only about 12 degrees. In northern latitudes, greater changes of temperature than this, often happen within an hour or two, during every month in the year.

The small variation of temperature between the tropics, is easily accounted for, since the days and nights there, are always of similar length, and the rays of the sun always vertical. But as we increase our latitude, or recede from the equator, there is a great difference in the course of the year, with respect to the direction of the sun's rays. In the winter, they fall so obliquely as to produce comparatively little effect on the temperature, even during the day, and as this is succeeded by a long night, the heat is constantly diminishing; hence even in the temperate regions of the earth, the cold towards the end of winter, becomes very intense.

On the contrary, during the summer in the temperate regions, the rays of the sun become vertical, and the nights are short, while the days are long, and thus the heat is constantly accumulating, and towards the end of summer, becomes nearly equal, to that of the tropics.

These are the causes, which account for the great difference between the temperature of winter and summer, in temperate latitudes, while at the equator, the season is nearly the same during the whole year.

The sudden changes of temperature, which take place in temperate regions, are caused, in general, by the greater or less clearness of the sky, and the consequent influence of the sun's rays, together with the direction of the wind. It is not denied, however, that in many

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What is said of the annual variation of temperature between the tropics? How is this accounted for? How is the great difference of heat and cold accounted for in temperate climates? What is said of the sudden changes to temperature in temperate climates?

instances these causes fail to account satisfactorily for the effect produced, and that these changes, are often experienced under circumstances, and to such degrees, as are not to be accounted for by any explanation which has yet been offered.

As we recede still further from the equator, and approach the poles, the difference between the length of the days and nights, at the different seasons, increases, until we arrive at 23 degrees beyond the polar circle, where the year is divided only into a day and a night.

During the months of winter, therefore, in the frigid zone, the cold becomes excessive, but in the summer, the sun is so long constantly above the horizon, that the heat in its turn becomes almost insupportable.

In the highest inhabitable latitudes, the heat of summer is often as high as 68, or 74 degrees of Fahrenheit, while in winter, it is down to 40 degrees below zero, thus making the difference equal to 146 degrees, during the year.

The variation of temperature in summer, in different degrees of latitude, is however, comparatively very small, the heat at 74° north latitude, being for a short time, equal to that of the cooler places, within the tropics.

Of the Seasons in different Latitudes.—Under the equator, there is a perpetual summer, and at the poles a perpetual winter, the four seasons, of Spring, Summer, Autumn, and Winter, being equally unknown under the extremes of heat and cold. These changes are experienced only in the temperate zones, and are most perceptible, and regular, between the latitudes of 38° and 60°.

From the 60th degree of latitude to the pole, there are only two seasons, the warmth of summer, immediately succeeding the cold of a protracted winter. In Russia, the immense mass of snow, which had covered,

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Where is the year divided only into a day and a night? Why does the heat become insupportable in the frizid zone? How great is the heat in the highest inhabitable latitudes? What is the annual variation of temperature in latitude 74° north? In what parts of the earth only, are the four seasons known?

and protected the earth, is generally dissolved in three or four days, about the middle of May, and then the grass and flowers make their appearance in as many days more. Thus has the Creator, by a sort of miracle, provided for the wants of those, who are destined to suffer the inconvenience, and confinement of long and dreary winters.

In these cold regions, did the interval which we in temperate climates call *spring*, succeed the winter, it is obvious that there would be no sufficient season for vegetation, and that consequently, such regions would be nearly uninhabitable.

Countries within the Tropics.—The line of the equator passes over the middle of the Islands of Borneo and Sumatra, and the southern parts of Africa, between Ethiopia, and Guinea, of the Old World, and across the continent of South America, over the mouth of the Amazon river, in the New World.

The tropical regions extend 23 degrees on each side of this line, forming the North and South Torrid Zones.

In the Eastern World, the North Torrid Zone includes, in Asia, the southern parts of China, the whole of Tonquin, one half of Hindostan, and Arabia.

In Africa, the same zone includes Abyssinia, Nubia, Guinea, most of the Great Desert of Sahara, and the unknown countries in the interior of that great continent.

The Southern Torrid Zone, embraces in Africa, most of the Island of Madagascar, the great country of Zanquebar, Ethiopia, Congo, and Lower Guinea.

In Asia, the same zone includes the Burman Empire, Cochin China, the southern portions of Hisdostan, and Arabia.

In the Western Continent, the Northern Torrid Zone,

Where does the warmth of summer immediately succeed the old winter? Through what countries does the equinoctial line pass? How far on each side of the equator, do the torrid zones extend? What countries in Asia lie within the north torrid zone? What countries in Africa? What countries in Africa lie in the south torrid zone? What countries in Asia? On the western continent, what countries are under these zones?

includes, in South America, Colombia, Venezuela, and Guiana; also Cuba, Hayti, and the Islands of the West Indies.

The South Torrid Zone, on the same continent, includes Amazonia, Peru, Bolivia, Brazil, Bahia, and Pernambuco.

The southern half of New Holland, lies within the South Torrid Zone, and the other half within the temperate region of the north.

Countries within the Temperate Zones.—The Temperate Zones extend from latitude 23°, to latitude 67°, north and south of the tropics, forming the North and South Temperate Zones.

The countries of the eastern continent, within the North Temperate Zone, are the whole of Europe except the northern parts of Sweden, and Norway, the Chinese Empire, most of Russia, Siberia, Tartary, and the northern parts of Hindostan.

The countries on the western continent, under the same zone, are most of Mexico, the whole of the United States, Labrador, New South Wales, Canada, and the unexplored countries lying along south of the Artic circle.

The South Temperate Zone, embraces, on the eastern continent, South Africa, and on the western, half of Brazil, La Plata, Patagonia, and the Promontory of South America, to Cape Horn.

Remark.—These great divisions of the earth, with respect to the zones, are intended to facilitate the enquiries of the pupil, when we come to treat of the Geography of Plants and Animals, which subjects are now to follow. The smaller divisions, when necessary, will be made in the course of our observations, on these subjects.

How far do the temperate regions extend? What countries of the eastern continent are within the north temperate zone? What countries of the eastern continent are under this zone? Does vegetation follow the degrees of latitude, or the lines of equal heat?

Isothermal Lines.—It has already been shown under the article *Isothermal Lines*, that the degrees of latitude in different parts of the earth, do not indicate the degrees of temperature, and it will be seen in the following article, that vegetation does not follow the lines indicated by the zones, but with greater, or less exactness, those of equal heat.

The Northerm Hemisphere is much more temperate than the Southern, at equal distances from the equator; thus pines 60 feet high, grow in Lapland, while at the Straits of Magellan, in South America, which is 10 degrees nearer the equator, no plants, which can properly be called trees, are known, all being reduced to the size of shrubs. We shall see hereafter, also, that there is a great difference in this respect, under the same degrees of north latitude in different places.

BOTANICAL GEOGRAPHY.

Among the numerous, and varied departments of Physical Geography, none are more interesting than those which pertain to the distribution of Plants, and Animals over the different parts of the earth, and to the former of these subjects, we now request the pupil's attention.

Dissemination of Plants.—By the dissemination of plants, we mean the dispersion of their seeds, spontaneously, or without human aid.

This dispersion has not been the result of blind chance, but is a part of the great plan of Infinite Wisdom to extend, and perpetuate the species.

We shall find too, that there are no bounds to this dissemination, so far as the means provided are concerned,—that mountains, seas, and oceans, are no barriers to their dispersion, and that climate only, prevents

What is said of the comparative temperature of the northern and southern hemispheres? What is meant by the dissemination of plants? What prevents the dissemination of the same species to every part of the earth?

the same species from occupying every part of the earth.

Number of the Seeds of Plants.—One of the most efficient means of perpetuating and disseminating plants, is by their vast number of seeds, so that, although great numbers are destroyed by birds and animals, there still remains enough to continue, and spread the species.

Sir Kenelm Digby informs us, that in 1660, there was preserved with great care in Paris, a single barley-plant, with 45 culms, or straws, all of which contained 18,000 corns of barley. The botanist, Ray, counted 32,000 seeds in the head of a single poppy, and 360,000 in the capsule of a tobacco plant.

Dodart calculated, that a certain elm tree produced 530,000 seeds per year; and yet these are units, when compared with the numbers produced by many other plants, the seeds of which are too minute and numerous to be estimated.

Some of the ferns, and especially the mushrooms, produce seeds so numerous, that no estimate can be made of their numbers. Several of the latter tribe, as the puff-balls, burst open at the top, like the crater of a volcano, and the seeds escape in such quantities, and are so fine, as to appear like a volume of smoke.

Duration of Seeds.—Although many seeds, as those of angelica, and coffee, require to be sown almost as soon as ripe, and cannot possibly be kept in a state to grow, for any considerable length of time, still the seeds of most plants, preserve their germinating principle for centuries, and some of them for ages.

Mirbel says, (in 1818) that he had witnessed the growth of seeds from Tourneforte's Herbarium, and which could not have been less than a century old; and that Home sowed some barley with success, which had been gathered 140 years. Wheat has been known to

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What is said of the number of seeds in different plants? What is said of the seeds of the puff-ball? What is said of the duration of seeds? How is it said the seeds of barley, wheat, and the grasses may be kept?

vegetate after being kept for ages, and the seeds of the grasses produce their kind, after being buried in the earth, to all appearance, for thousands of years.

Various means of Dissemination.—Many plants have their seed vessels furnished with springs, so that when they become dry, and the seeds ripe, they open with a jerk, and throw their contents to a considerable distance.

The seeds of the Syngenesious tribes, are provided with a feathery crown, which opens like a parachute, and by which, the little particle is floated for miles through the air. Who has not seen the seeds of the Dandelion migrating in this way from one place to another? During strong winds, the broadest rivers, and the highest mountains, may be crossed in this manner.

No place is closed against the intrusion of the seeds of various sorts of *moulds*, as that of bread, or cheese, both of which are vegetable productions, and require seeds for their growth, equally with corn and grass. These are so light as to float along like smoke, and thus find their way into closets and cellars, where they grow, on substances suited to their nature.

Heavier seeds are provided with wings. Thus those of the elm are enclosed in a membrane, by which they sail along to considerable distances. The maple and ash have also appendages of a similar kind, by which the same effect is produced.

The *Erigeron Canadense*, a weed now disseminated almost every where, on both sides the Atlantic, is a native of Canada, and is supposed by Linnæus to have been transported through the air from America to Europe, a thing, says Mirbel, not at all impossible.

Some seeds are closely sealed, and are apparently designed for maratime voyages. Among these are the

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What is said of the means by which seeds are disseminated? In what manner are the seeds of syngenesious plants, as the dandelion, transported from place to place? What is said of the seeds of various sorts of plants? What seeds are provided with wings as a means of transportation?

cocoa-nut and *cashew-nut*, which are in a state to grow, after being in the water for weeks, or even months.

In this manner, the cocoa-nut, an article of food, absolutely necessary to the millions who inhabit the islands of the Pacific, and South Seas, has been transmitted by the currents of the ocean, from island to island, until at the present day, none are without it—a striking illustration of the adaptation of means to the wants of his creatures, by the Great Head of the Universe.

Besides the currents of the ocean, which in many instances are known to have transported seeds to the distance of thousands of miles; rivers, in like manner, bring down from their head waters, the germs of plants, the native soils of which, have never yet been explored by civilized beings.

Many seeds are provided with hooks, by which they catch hold of any fibrous substance, and are thus carried from one place to another. The wool of sheep, which, in the course of commerce, is transported from one nation to another, has often, in this manner been the means of introducing plants across the widest oceans.

Squirrels, dormice, rats, and birds, all conspire, in a greater or less degree, to the same end.

They first hoard up their winter stores in places where the heat of summer causes what remains to vegetate, and thus these animals unconsciously do their part in carrying on the great work of preserving and spreading the species.

Birds often carry seeds to great distances. Thus the Dutch, in order to monopolize the trade in nutmegs, destroyed the trees in such of the Spice Islands as they could not watch. But in a short time, these very islands were restocked with nutmeg trees, the seeds being carried from one island to the other by birds.

Thus did nature refuse to sanction any such invasion of her rights.

These are some of the principal means by which the

What is said of the transportation of seeds by the currents of the ocean and rivers? What other means are noticed by which seeds are disseminated? How do squirrels and birds conspire with the other means to perpetuate vegetation?

great work of preserving, and spreading the vegetable kingdom is carried on. At present, however, we shall see that many species are confined to particular stations, though other places are perhaps as well fitted for their vegetation and growth. But by such means, together with the help of man, it is most probable that, at least, all useful plants, will finally be found in every station fitted to their growth, and that the entire zones of the earth, under similar parallels of latitude, will be occupied by the same species.

But climate being the great barrier to the indiscriminate growth of the vegetable kingdom, no power of man can induce tropical fruits to flourish in northern latitudes; nor, with a few exceptions, can the plants of cold regions be made to endure the climate of the tropics. 'Here nature is too strong for man.'

GEOGRAPHICAL DISTRIBUTION OF PLANTS.

It is the scale of atmospherical heat, and the presence, of moisture, which generally determines the geography of plants. Hence in the fierce climate of the torrid zone, we have only to ascend to certain elevations in order to find the vegetables of the temperate, and even the frozen regions.

Near the equator of South America, the oak, which is common to the north temperate zones of Europe and America, but unknown in the valleys of the tropics, grows at the height of more than 9000 feet, and never, in that region, descends lower than 5500 feet.

A good illustration of the zones of the earth, with respect to the geography of vegetation, is presented by the different plants growing at different heights on the same mountain.

Thus, on the volcano of Teneriffe, one of the Canaries, in north latitude $28\frac{1}{2}°$, there are six zones of vegetation. First, the region of *vines;* second, that of *lau-*

Is it not probable that the entire zones of the earth will finally present vegetables of the same species? What are the great physical causes which determine the geography of plants? In what elevations do plants of the temperate zones flourish near the equator.

rels; third, that of *pines;* fourth, that of the *retama* (an Alpine broom); fifth, the region of the *grasses;* and sixth, that of the *mosses.*

But this island, though an illustration of the vegetable zones, is too far from the equator, to be brought as an example of the actual productions of the earth, from the torrid, to the frigid zones. We will therefore enumerate, at this place, a few of the species, as they occur on the planes of the earth, from the torrid, through the north temperate zone.

In the region of the equator, we find the Bread Fruit, Cassava, Plantain, and the Spices, Nutmegs, Pepper, and Pimento.

Next, in latitude from 20° to 30°, grow the Sugar Cane, Coffee, Orange, Lemon, Date, Pine Apple, and Fig.

In the next zone of vegetation, we find Tobacco, Maize, Sweet Potatoe, Live Oak, Mahogany, Cotton, Rice, and the Vine. This extends from about 30° to 40°.

Many of these plants, however, grow almost indiscriminately, within the warm regions; but flourish in the greatest perfection, nearly in the orders in which they are here placed.

In the temperate region, from about 35°, to 45°, flourish the Apple, Pear, Peach, Melon, Mulberry, and Apricot. This is, also, the region for Wheat, Maize, Rye, and Barley. Wheat may also be grown to the 60th degree, and Rye and Oats, a few degrees higher. The Oak, Beech, and Maple, are among the timber trees of this region.

North of 45°, and extending to about 65°, is the region of the evergreens, the Pines and Firs, which are among the noblest and most lofty of vegetables. These extend within the arctic circle, and with the Willow and Birch,

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What are the plants which form the six zones of vegetation on Teneriffe? What plants grow in the region of the equator? What are the examples of vegetables or plants, growing between 20 and 30 degrees of latitude? What are the examples of the next zone? What plants flourish in the temperate regions, from 35° to 45°? What are the examples of plants from 45° to 65°?

which there dwindle into shrubs, compose the forests of the frozen regions.

Advancing within the arctic circle, vegetation rapidly diminishes in size, and the species become few in number, consisting of dwarf Willows and Birches, and a few herbaceous plants, until we come to the 70th degree of latitude, when trees are no longer found, and vegetation consists of Mosses, Lichens, Ferns, and creeping plants, with a few low shrubs, which still yield berries, some of which have an agreeable flavor.

The above enumeration of vegetables, which grow from the equatorial to the polar regions, are intended only as common examples of such as are found on the general surface of the earth, and without reference to the changes which mountains produce on the geography of plants, which subject will be considered hereafter.

NUMBER OF PLANTS.

That the student may have some conception of the importance of Geographical Botany, and of the labor which has been bestowed on the science of Plants generally, we here insert the number of known, and estimated species, from the most recent authorities.

Explanations. — The word *phænogamous*, means plants which have visible stamens, and pistils, as the lily, apple, and peach.

Cryptogamous, signifies plants in which no stamens or pistils are visible, as the ferns, mosses, and mushrooms.

De Candolle, in his Geography of Plants, says that the terrestrial species and varieties may amount to between 110,000 and 120,000.

Mr. Lindley thinks, in the present state of science, that we cannot speculate on more than 80,000 phænogamous, and 10,000 cryptogamous plants.

If we take, says he, 37,000 as the number of published phænogamous species, and then add, for the undiscov-

What plants are found above the 70th degrees of latitude? What are the meaning of the words, phænogamous, and cryptogamous?

ered species, in Asia and New Holland, 15,000; in Africa, 10,000; and in America, 18,000; we shall have 80,000 species; and if 7000 be the number of published cryptogamous plants, and we allow 3000 for the undiscovered species, making 10,000, there would be in the whole, 90,000 species of plants.

Comparative Number of Plants in different Regions. Humboldt estimated the number of phænogamous plants to be 38,000; and the cryptogamous ones at 6000.

According to the same author, the phænogamous plants are thus distributed:—

In Europe - - - - - -	7000
In the temperate regions of Asia -	1500
In the temperate regions of America -	4500
In America between the tropics -	13000
In New Holland and the Islands of the Pacific,	5000

Humboldt also estimated that more than one half of this number were found within the torrid zone, though this part of the earth had been least explored by botanists.

The rapid diminution of species, as we leave the torrid, and approach the frigid zone, is shown by the estimate, that the island of Madagascar contains 5000 species; one of the German States, 2000; Sweden, 1300; Lapland, 500; Iceland, 500; and Spitzbergen, only 30 species.

These estimates, reduced to comparative numbers, show the proportions of plants growing in latitude 0°, to be 12; in 45°, 4; and in 68°, 1. Thus making up the proportions, from the equator to the polar circle, as the numbers 12, 4, 1.

What is the actual number of species known? What proportion are phænogamous, and what cryptogamous? What is the estimated number of species? What proportion of phænogamous plants are found in the torrid zone? What proportion of species is found in Madagascar, and the other countries mentioned? What are the relative proportions at the equator, and in latitudes 45°, and 68°?

Plants peculiar to different Countries, or Situations.

It has already been stated that, notwithstanding the natural means provided for the distribution of plants, there are still many species confined to particular countries, under similar parallels of latitude, and therefore independently of temperature.

Thus, in the temperate regions of Europe and America, there is almost a complete diversity in the species.

De Candolle states, that out of 2891 phænogamous plants described by Pursh, in the United States, only 385 are found in northern temperate Europe.

Humboldt, in his travels through South America, found only 24 species, which are common to America and the Old World, and these were grasses and sedges.

The same principle is confirmed by Mr. Brown, who ascertained that of 4100 species, discovered in Australasia, there were only 166 common to Europe; and of this small number, several were probably transported to the continent by man.

Species belonging to Islands.—In islands at great distances from continents, the number of species is usually small; but there is always a proportion which are found nowhere else. So far as the species of such islands are not peculiar to them, they are generally common to the nearest main lands.

The islands of the great Southern Ocean illustrate this general law; those nearest America, containing most American, and those nearest India, containing most Indian plants.

In the Canaries, out of 533 phænogamous species, there are 310 peculiar to these islands, while 23 are identical with those of the African continent.

But the island of St. Helena presents a still more striking example of the same law. This island is situ-

What is said of species confined to particular countries, or situations? What number of plants were found common to Europe and America? What number, to Europe and Australasia? What is said generally, of the species belongimg to islands? What islands are mentioned as illustrating this general law? What is said of St. Helena, in particular?

ated at the distance of more than 1000 miles from any other land, whether island, or continent; and out of 61 native species of plants found on it, only *two*, or at most *three*, are found in any other part of the globe.

Plants which are widely disseminated.

If, on the one hand, there are many species of vegetables which are peculiar to certain countries, or situations, so on the other, there are a few, which, without the aid of man, are widely disseminated, and are found in nearly all climates, and situations.

Fir Tribe.—Among these is the cone-bearing, or fir tribe, consisting of the pines, firs, and larches. These are natives of most parts of the world, from the perpetual snows, and inclement regions of arctic America, to the warmest portions of the Indian Archipelago. These species, however, attain their greatest altitudes in the north temperate regions of America, and of China, Siberia, and Norway.

'No order,' says Mr. Lindley, 'can be named of more universal importance to mankind than this. Gigantic in size, rapid in growth, noble in aspect, robust in constitution, these trees form a considerable part of every wood, or plantation in cultivated countries, and of every forest where nature remains in a savage state.'

One of this tribe, growing in the island of New Zealand, and called *Dammara Australis*, attains the height of 200 feet. But this is excelled by the stupendous pines of the north-west of America, one species of which, the *Pinus Lambertiana*, is said to attain the height of 230 feet.

Cruciferæ, or the Cruciferous Tribe.—This tribe includes the Mustard, Cress, Horseradish, Cabbage, and several other useful plants. It is a very extensive natural order, and is here brought as an example of the wide dissemination of species.

What species are mentioned as being widely disseminated? What are the heights of some of this tribe? What common plants does the cruciferous tribe embrace?

In certain instances, the hand of man has probably aided in their distribution, but it is the native species, only, which are here enumerated.

The geography of this tribe is among the most extensive which botanists have examined; and that it has been studied with great care, will be seen by the following account of the distribution of its species.

Of these, 166 species are found in northern and middle Europe; 178 on the northern shores of the islands of the Mediterranean; 45 are peculiar to the coast of Africa; 184 to Syria, Asia Minor, Taurus, and Persia; 99 to Siberia; 35 to Japan, China, or India; 16 to New Holland, and the South Sea Islands; 6 to the Isle of France, and neighboring islands; 70 to the Cape of Good Hope; 9 to the Canaries and Maderia islands; 2 to St. Helena; 2 to the West Indies; 41 to South America; 48 to North America; 5 to the islands between North America and Kamtschatka; and 35 are common to various places in the world.

Considered with regard to temperature, this tribe stands as follows:—

In the Frigid Zone of the Northern Hemisphere,	205
In all the Tropics, (chiefly in the mountains,)	30
In the Northern Temperate Zone, - -	548
In the Southern Temperate Zone, - -	86

Geography of Bread Corn.—The native countries of wheat, rye, and the other grains, now employed in all civilized nations as the food of man, are, with an exception or two, unknown. Maize is a native of South America, and it is believed that rice came originally from India; but it is most probable that wheat and barley, were natives of many countries.

These grains, at the present time, are cultivated in most civilized regions, where climate does not interdict their growth.

Beginning towards the north, the grains which come

What is said of the extent of the geography of this tribe? What is said of the native countries of bread corn? What grains come to maturity in the highest latitudes?

to maturity in the highest latitudes, are barley and rye. These are cultivated in the Russian possessions, in latitudes 57° and 58°.

In Europe, the grains which extend farthest north, are barley and oats. These, which in milder climates are little used for bread, afford to the inhabitants of the northern parts of Norway and Sweden, and of a part of Siberia, Scotland, and Ireland, their chief vegetable nourishment.

Rye comes next south of these, and is the prevailing grain in the north temperate zone of Europe, namely, in the south of Sweden, Norway, and Denmark, and in the north of Germany, and a part of Siberia. It is, also, the chief grain in the region bordering on the Baltic Sea. In some parts of this zone, buckwheat is raised, and barley is cultivated for the manufacture of beer.

Next follows a zone in Europe, and Western Asia, where rye disappears, and wheat almost exclusively furnishes bread. To this zone belongs the middle or south of France, England, a part of Scotland, a part of Germany, Hungary, the Crimea, and Caucasus. There the vine is also found, and wine takes the place of beer.

Then comes a circle, where wheat still abounds, but no longer exclusively furnishes bread; rice and maize being more or less employed. To this circle belong Portugal, Spain, part of France, Italy, and Greece. Also the countries to the east, as Persia, Northern India, Arabia, Egypt, Nubia, Barbary, and the Canary Islands. To this zone belong the middle of the United States.

In the eastern part of the Old Continent, in China and Japan, and the southern parts of India, rice chiefly takes the place of grain.

In the southern parts of North America, wheat and rye are not exclusively employed, as in Europe, rice and maize being also largely cultivated. In the extreme south, rice predominates.

In the Torrid Zone, maize predominates in America, and rice in Asia; in Africa, both are raised in nearly equal quantities.

In this zone, besides grain, there are several sorts of

What are these latitudes?

vegetables which take the place of bread. In the New Continent, yams, manihot, and the sweet potatoe, as well as the banana, furnish universal articles of food. In the same zone, in Africa, yams, manihot, and several vegetables peculiar to that country, take the place of bread.

In the south parts of the East Indies, and on many of its islands, several sorts of palms, which produce sago, sweet potatoes, yams, and bread-fruit, compose the chief diet.

In the islands of the South Sea, and the Sandwich Islands, grain entirely disappears, and is replaced by the bread-fruit, pisang, and tacca.

In the high lands of equatorial America, elevation takes the place of geographical latitude. There maize grows at the height of 7200 feet above the level of the sea, and is the predominant grain at the elevation of 3000 to 6000 feet. Below 3000 feet, it is associated with the bread-fruit, and pesang; while from 6000 to 9200 feet, the European grains abound, wheat in the lower, and rye and barley, in the higher regions.

Above 9200, and up to 12,300, the common potatoe alone, is cultivated.

Vegetable Zones of the Earth.—From the above, it appears, that in respect to the predominating kinds of grain, the earth may be divided into five grand kingdoms, or divisions, each being distinguished by the kind of bread corn it produces. Beginning at the south, we have the kingdoms of Rice, of Maize, of Wheat and Rye, and lastly, of Barley and Oats.

The first three are most extensive: Maize has the greatest range of temperature; but Rice supports the greatest number of the human race.

Vegetation of the Torrid Zone.—The vegetation of the Torrid Zone, is characterized by a magnificence of

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What are the bread corn kingdoms into which the Northern Hemisphere may be divided? What three grains are most extensively cultivated? Which has the greatest range of temperature? Which supports the greatest number of the human race? What is said of the vegetation of the Torrid Zone?

size, and a grandeur and beauty of appearance, which the vegetable kingdom nowhere else exhibits.

Under the beams of a tropical sun, where the earth is well supplied with moisture, the strongest aromatics, and the most luscious and juicy fruits, arrive at their full perfection, and man is there supplied with a variety, and profusion of delicious vegetables, to which other parts of the globe are entire strangers.

In some regions, the food of man consists almost entirely of the bread-fruit, cocoa-nut, and a few other vegetables. In the tropical parts of New Holland, agriculture is unknown, the inhabitants subsisting on these spontaneous productions.

In the equatorial parts of South America, the largest trees are adorned with flowers which are larger, more odoriferous, and more beautiful, than those of any herbaceous plants of the temperate zones.

Vines, and parasitic plants of various kinds, are often seen climbing to the tops of the tallest trees, and binding whole forests, as it were, into a single thicket. Such is the interlacing of stems and branches, vines and parasites, and such the profusion of flowers, with which each is adorned, that even the experienced botanist is constantly liable to be deceived, and to make mistakes, by confounding the leaves, fruit, and flowers of the different species with each other.

Trees of enormous growth.—A large proportion of the trees of the majestic forests of South America, are more than 100 feet in height, while some, especially the palms, have an elevation of 150, or even 200 feet. Humboldt measured a bomax, a species of cotton tree, which was more than 120 feet high, and 15 feet in diameter.

Near the village of Turmera, which lies south-east of the city of Caraccas, is the famous tree called *Zamang del Guayre*, a species of Mimosa. Its branches form a hemispherical head more than 600 feet in circumference. The height of the trunk is about 60 feet, and the branches bend towards the ground, from which they hang in a regular circle at the height of 12 or 15 feet.

What are the names and dimensions of some of the large trees of hot climates?

The dragon tree, in the island of Teneriffe, is another specimen of immense growth. Its trunk is about 60 feet high, and its circumference, near the root, 48 feet.

But the Adansonia, usually called *Baobab*, a species of the cotton tree, is of still greater dimensions. Some of these trees growing in Africa, on the river Senegal, and on the Cape de Verd Islands, are said to measure 34 feet in diameter, or more than 100 feet in circumference. The height of this species is, however, not in proportion to the diameter of the trunk.

Notwithstanding the boasted superiority of tropical forests for grandeur and beauty, still there probably is no tree on earth, which, on the whole, excels some species of the pine of North America. Some of these, as already noticed, elevate their tops to the height of 230 feet. Their trunks are 120 feet, without a limb, and as straight and erect, as though they had been formed in reference to mathematical accuracy. The diameters of these enormous trees, near the ground, are 8, 10, and even 12 feet, and their ever-green conical tops, present a symmetry and beauty of form, which is without a rival in the vegetable kingdom.

AGE AND DEATH OF PLANTS.

Plants, like animals, unless destroyed by disease, or casualties, are doomed to die of old age.

In their terms of life, like those of animals, there is a great difference. Some insects live but a single day, or even but a few hours, while other animals, as the eagle, tortoise, and some others, are said to live an hundred years.

Plants, though their periods of existence are much longer than those of animals, differ quite as much in their ages.

Some of the mushrooms, which spring up in the night, arrive at their full maturity before noon, and die of old age before the setting sun.

Annual plants, as garden flowers, and many esculent

In what respects is the American pine superior to any of the tropical plants? What is said of the death of plants?

species, such as the cucumber and squash, come to maturity, and finish the periods of their lives in three or four months.

Plants with woody stems, have their lives prolonged to various periods, generally bearing fruit, with the return of the season, for many years after they have arrived to maturity. There are, however, a few species, which grow for several years, and die after once bearing fruit. Such is the umbrella tree (*Corypha umbraculifera*) of hot climates, the leaves of which are 20 or 30 feet in length.

Ages of particular Trees.—On the contrary, there are some trees now living, whose existences appear to have commenced long before the Christian era, as will be seen by the following account of these aged individuals.

The yew trees of Surrey, in England, are said to have stood there in the time of Julius Cæsar, and consequently are 2000 years old.

An apple tree, now growing in the city of Hartford, was brought from England, by George Wyllis, in 1638, and therefore must be 200 years old.

The following are among the most remarkable cases of vegetable longevity which have been recorded:

	Years old.
A fig tree of Palestine,	780
An olive tree in Asia Minor,	850
A live oak in Louisiana,	1000
Sycamore trees in Palestine,	1050
A pine in Asia Minor,	1890
A cedar on Mount Lebanon,	2120
The chestnut at Mount Etna,	2600
A sycamore of the Bosphorus,	4000
A baobab tree in Senegal,	4000

Some of these ages were ascertained by well known historical events, and others by felling the tree, and counting the concentric rings, which indicate the annual growth of the wood.

Give a general account of the facts with respect to the ages of trees.

The common oak, if permitted, generally lives from 600 to 900 years; but in our country, among civilized people, they are very rarely suffered to acquire a tenth part of this age, being most frequently cut off in their infancy, by the ruthless hand of man, and consigned to the flames.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

Although, since animals have the power of locomotion, we might expect they would be less confined to particular regions than plants, yet we shall find, that in their geographical distribution they follow a similar law.

Certain species of plants, we have seen, are indigenous in certain regious, out of which they are rarely, or never found, while other species are indigenous to a variety of climates, or have been transplanted by the hand of man into regions remote from each other, in order to supply his wants.

The same general fact is found to hold, with respect to the distribution of the higher orders of animals. Some are confined to particular countries, or zones, out of which they never wander. Others are natives of all climates, and situations, while those which are the servants or favorites of man, have been acclimated with him, to every region which he inhabits.

Animals of the Old World.—The animals of the Old World, with an exception or two, are of different species from those of the New. Every quadruped, without exception, found in South America, presented a new species, or a new genus, to the naturalists of Europe. And more recently, when the quadrupeds of New Holland were examined, there was found existing there, more than forty species, not one of which were before known to naturalists, nor has an individual of these species been found in any other part of the world.

The elephant, the rhinoceros, the hippopotamus, the

What general similarity is there between the geographical distribution of plants and animals? Are the animals of America of the same species as those of the Eastern continent or not? What is said of the quadrupeds of New Holland?

cameleopard, the camel, the dromedary, the buffalo, the horse, the ass, the lion, the tiger, the apes, the baboons, and many other species of quadrupeds, existing in different parts of the ancient world, were not one of them found in the New Continent.

Animals of the New World—On the contrary, the tapir, the lama, the pecari, the jaguar, the cougar, the agouti, the sloth, several species of bears, the opossum, the bison, and a vast number of inferior animals, are peculiar to the American continent, and are nowhere else to be found.

Animals found on both Continents.—The only region where the species found on both continents are the same, is where the lands approximate each other, towards the north, so that in the winter ice bridges will allow such quadrupeds as can bear the cold of the arctic circle, to pass from one to the other. From this circumstance, the arctic region has become a province, which contains many animals common to the Old and New Continents.

Zoological Provinces.—Dr. Prichard has divided the earth into several zoological provinces, or regions, each of which is the residence of a distinct group of animals. The arctic region is one of these provinces, and is peculiar in containing species belonging to both continents, as above described.

These provinces often contain *genera* common to each other, but the *species* are different. Thus the lion of Africa, and the cougar of America, both belong to the genus Felis, but the two species are different in color, form, and power, and inhabit countries as distant from each other, as Africa and America. In this instance, therefore, the species never inhabit the same province. But in Africa, the panther and leopard, two other species of the same genus, dwell together; and in America, the jaguar, still another of the Feline tribe, is found with the cougar.

Where is the only province in which the animals of the Old and New World are in common? How is this community of species accounted for? What is the difference between a genus and species?

Animals of South Africa.—The south of Africa, extending to the Cape of Good Hope, is a zoological province, and is found to contain several animals peculiar to itself, as the cameleopard, the cape buffalo, several remarkable antelopes, as the gnu, and spring-bock, and one species of rhinoceros.

New Holland.—New Holland, and the islands in its neighborhood, is another distinct animal kingdom, and much better defined than any other, since, as already noticed, it contains no animals to be found in any other part of the globe.

One tribe of animals found here, presented phenomena before unheard of, and which at once astonished and confounded all the naturalists of the day. This was nothing less than an *egg-laying, warm blooded quadruped.*

Every quadruped before known, which continued its species by means of eggs, belonged to the amphibious tribes, as the crocodile, lizards, and tortoise. But here it appeared that nature had found out a new way, and it was a long time before naturalists, who had not actually seen such a strange phenomenon, could be made to believe that such an anomoly in the Animal kingdom, actually existed. This curious tribe is entirely confined to New Holland, at the present day.

Another remarkable tribe found in the same Island, are called *marsupial* animals, which term denotes those which are furnished with a *bag*, in which they carry their young. A portion of this tribe was known before as the opossum, of America. But the singularity presented by the quadrupeds of New Holland is, that nearly all which have been found there, are marsupial animals. They amount to about forty species, and include the wombat, kangaroo, kangaroo-rat, &c.

But our limits will not allow a description of all the zoological provinces mentioned by authors, and we must,

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What peculiar animals does South Africa contain? What is said of New Holland as a Zoological province? What remarkable phenomenon does one tribe of New Holland animals present? What is said of the marsupial tribe of New Holland?

therefore, now turn our attention to such species as are more widely distributed over the earth.

Quadrupeds which inhabit considerable portions of the Globe.

Of the *Carnivora*, or *Flesh-eaters*, the Feline, or Cat tribe, are extensively spread, although most of them belong to warm climates. We speak here only of animals in their wild state.

Of this tribe, 28 species have been determined, consisting of the lion, tiger, leopard, cougar, lynx, &c. But still the different species are geographically separated, however wide a range each group may have in their own dominions.

Of the 28 species of this tribe, not one is common to the Old and New Continents. Even the lynx of Canada, which was formerly supposed to be identical with that of the Eastern world, is now considered a different species.

The lion is most formidable in Africa, to which, and a part of Asia, it is now confined. Formerly, this animal was found in Europe, and, indeed, according to Cuvier, it once roamed over three fourths of the Old World. It is now, owing to the increased domain of man, driven into a comparatively small region. There are two species, the African, and Asiatic, in the latter of which, the male has little or no mane.

The tiger is confined to Asia, but extends his range beyond the Himmaleh mountains, into Chinese Tartary, but is by far most common in the hot regions of Hindostan, and especially in the jungles, along the delta of the Ganges.

Canine, or Dog Tribe.—The geography of this tribe is by far more extensive than that of the former, or indeed, of any other race of wild animals.

To what regions are the feline, or cat tribe confined? How many species of this tribe are known? What are examples of this tribe? To what regions is the lion now confined? How extensive was the range of the lion formerly? Where is the tiger found? What is said of the geographical range of the dog kind, and especially of the Fox?

Of this tribe, the fox excels all the others in the extent of his habitation, being distributed to every climate, and nearly every station on the earth. In Nova Zembla, and along the shores of the Arctic ocean, as near the pole as man has ever penetrated, troops of these animals are seen. From these frozen regions, down to the hottest portions of the Torrid Zone, as Guinea, and the equatorial regions of Asia and America, the fox is found.

The wolf, one of the same tribe, is seldom found below the middle portion of the Temperate Zone, but extends to the cold regions of Russia and Siberia.

The domestic dog, of which there are many species, has followed his master to every region and climate, inhabited by man; and in no instance, is the varied and protecting care of Providence over the animal creation, more conspicuous than in this.

The original stock of the dog is supposed to have been the wolf, and yet at the present day, owing to domestication and climate, the varieties of the dog are almost as numerous as the regions in which he dwells, and into whatever climate man has seen fit to take this affectionate and faithful animal, he has, after a time, acquired clothing according to his wants. Thus the dog of the arctic regions, so useful as to supply the places of horses, and camels in more temperate climates, is, like his neighbor, the white bear, covered with a thick coat of hair, which enables him to bear comfortably, the cold of that frozen climate.

On the contrary, the dogs of Africa are absolutely without the least covering, except the skin, and can with difficulty bear the summer of a temperate climate. Between these two extremes, these animals, where the species are kept distinct, have acquired an amount of clothing agreeably to their wants; a striking proof of the care and design of the Creator, in the organization of animal beings.

How great is the range of the wolf? Where is the domestic dog found? What is said of the varieties of the domestic dog? What is the fact with respect to the adaptation of the dog's clothing to the climate in which he is?

The Pachydermatous, or Thick-Skinned Tribe.—To this tribe belong the Elephant, Rhinoceros, Tapir, Hippopotamus, and several others.

Of the elephant, there are only two species, the African, and the Indian; the latter being considerably the largest.

They exclusively inhabit the hottest climates, and are the largest and most sagacious animals known.

Of the rhinoceros, there are several species, all of which occupy distinct countries. That inhabiting Africa has two horns, while the species belonging to India, and China, has a single horn.

Another species, found in Sumatra, has one horn, and the rudiment of a second.

Of the hippopotamus, there is only a single species. It is a huge, and ferocious animal, and is at present confined to the rivers of middle and south Africa.

Formerly this animal inhabited the Nile, but has long since disappeared from that region.

The tapir, presents two species, one in South America, and the other inhabiting Sumatra, and the islands in its vicinity. They are aquatic, stupid animals, and have never been found, except in these two provinces.

Quadrupeds inhabiting Islands.—We have seen that plants found on islands, unless peculiar to them, were of species belonging to those of the nearest continent.

The same fact is true with respect to quadrupeds, those on islands, generally forming a part of such species as are found on the adjacent main land.

Small islands, remote from continents, are, however, generally destitute of land quadrupeds, except such as appear to have been conveyed there by man.

Examples of this fact occur in the islands of the Pacific Ocean, no quadrupeds having been found on any of them, except dogs, hogs, rats, and, on some, a few

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What animals belong to the thick-skinned tribe? How many species of the elepant? How many species of the rhinoceros? Where are they found? What is said of the hippopotamus? Where are the two species of the tapir found? When common species of animals, are found on islands, where must we look for the same? What is said of the destitution of small, remote islands of quadrupeds? What animals are found on the islands of the Pacific ocean?

bats. The first three were carried there by man, from the coast of New Guinea; and the bats probably found their way there from the nearest coast.

The same fact is true in respect to all small islands, which are remotely situated from any continent, or large island.

We have seen that large islands contain quadrupeds, sometimes in abundance, but those are generally peculiar to them, as already noticed with respect to New Holland. Sumatra, also, has its quadrupeds, some of which are of the largest size, as the elephant, and rhinoceros. It also has tigers, bears, and monkeys, most of which are of species peculiar to that island.

Comparative Sizes of Quadrupeds, in the Eastern and Western Continents.

From the first discovery of the New World, European naturalists asserted that its animals were generally of an inferior size to those of the same tribes found in other parts of the world. Even animals brought from Europe, it was maintained, deteriorated, after a few generations in America. The same doctrine is advanced by most foreign zoologists at the present day.

This prejudice, undoubtedly, arose originally, from the fact that the Western Continent is destitute of the larger quadrupeds, found in other extensive countries, as the elephant, rhinoceros, and hippopotamus.

We are also destitute of the lion and tiger, and it is more than probable, that at the time when America was first explored, and when little was known with respect to the distinction of species, that the jagaur and cougar, were considered the deteriorated representatives of these animals.

But, from whatever cause this opinion has originated, and however general it may have become, that it is an egregious error, and that, on the contrary, the animals of the same tribes are much larger on the Western, than on the Eastern Continent, is shown by the follow-

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What is said of the quadrupeds of Sumatra? What have been the assertions of naturalists with respect to the sizes of American quadrupeds?

ing comparisons. The weight of animals in Europe was furnished by Buffon,—that of American animals is taken from the 'History of Vermont,' by the Rev. Dr. Williams.

Animals.	Weight in Europe. lb.	oz.	Weight in America. lb.	oz.
The Bear,	153	7	456	0
Wolf,	99	8	92	0
Deer,	288	8	308	0
Red Fox,	13	5	20	0
Porcupine,	2	2	16	0
Martin,	1	9	5	4
Polecat,	3	3	7	8
Hare,	7	6	8	0
Rabbit,	3	4	7	0
Weasel,	2	2	12	0
Ermine,	8	2	14	0
Beaver,	18	5	63	8

From these comparisons, it would appear that, at least, so far as this table extends, the quadrupeds of America of the same tribes, are, in the average, full one third larger than those of Europe. The grizzly bear of the Rocky Mountains was unknown to Dr. Williams, otherwise he could have offered an American specimen of that race, of at least twice the weight of that in the table.

MIGRATION OF ANIMALS.

By *migration*, we mean the passage of animals, in flocks or herds, from one place to another.

These journeys are directed by instinct, and are generally undertaken in quest of food, or a warmer climate.

In many instances, animals perform regular annual migrations, from one section of country to another, in quest of food, moving with the advance of the seasons,

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What is proved with respect to the comparative sizes of animals in Europe and America? What is meant by the migration of animals? What are the motives which direct animals to migrate?

from north to south, or the contrary. The vast herds of bisons, west of the Mississippi, migrate hundreds of miles backwards, and forwards, every season; moving to the north in the Spring, and to the south in Autumn, thus finding green pasturage the whole year.

In other instances, the migrations of animals are only occasional, and often depend on the severity of the season, and the consequent scarcity of food in their own dominions.

Thus, during uncommonly hard winters, the black bears of Canada migrate to the United States; but, in ordinary seasons, they remain and hybernate in the north.

Mr. Pennant informs us, that when the rats of Kamtschatka become too numerous to find sufficient provisions, they gather together in the Spring, and proceed in great bodies, westward, marching straight forward, and swimming over lakes, rivers, and arms of the sea, by which great numbers perish by drowning. They continue their journey to the distance of 800 miles, eating up every vegetable in the tract through which they pass. Few arrive at the end of the journey, and none ever return.

A similar, but still more extraordinary account, is given of the leming, one of the rat tribe, which migrates from the mountains of Kolen, in Lapland.

These little animals, once in about twenty-five years, leave their native mountains, and in vast multitudes, march forward in lines, which are about three feet from each other, and which, where the ground will admit, are exactly parallel. They go directly forward through rivers and lakes, and when they meet with stacks of hay, or corn, they gnaw their way through them, instead if passing round. They are followed in their way by bears, wolves, and foxes, which prey incessantly upon their numbers, and multitudes are drowned in passing rivers and lakes. Still, those which remain, go forward, as if impelled by necessity, and passing through Finmark and Nordland, immediately enter the Western ocean, where, after swimming about for a while, they perish in the water.

GEOGRAPHICAL DISTRIBUTION OF BIRDS.

Notwithstanding the great locomotive powers of Birds, and in consequence of which we might expect that their geography would be extended; still, they afford no exception to the general law, already explained, with respect to quadrupeds, and plants; certain species being circumscribed within definite limits.

Thus, within similar latitudes, we find one assemblage in the Brazils, another in New Holland, a third in Central Africa, and a fourth in India.

This law is strikingly illustrated by the Parrot tribe, a very extensive and variegated genus, which inhabit the tropical regions of America, Africa, and Asia.

But, notwithstanding the variety of species which each country presents, it is stated by Dr. Prichard, that not an individual of one country, is common to the other; each country having species peculiar to themselves, and which are nowhere else to be found.

Another illustration of the same principle, is afforded by the *Trochilus*, or Humming-Bird tribe, all of which are peculiar to the New World; and many species are peculiar to islands, and small sections of country, out of which they do not exist.

Several of the Grouse tribe are equally exclusive in their range. The common grouse is found nowhere in the known world except in Great Britain; and the pinnated grouse (*Tetrao cupido*) is said to be found nowhere in the Eastern States, except on a certain plain in New Jersey, another in Connecticut, and a third on Long Island.

Although these may be taken as rather rare examples of the exclusive habitations of birds, still it may be considered that every country has its peculiar species, many of which migrate north and south with the seasons.

Do birds present any exception to the general law of the distribution of animals? What is said of the species of parrots found in different countries? What is said of the humming-bird, as an illustration of this law? What is said of the range of the grouse tribe?

Species which are common to different regions.—Of all cosmopolites, perhaps, the Wild Goose (*anas anser*) is the best example, exceeding in its range of countries and climates, both man and dog, and even the fox himself.

This bird, indeed, appears to be a general inhabitant of the globe, being found not only in all latitudes and longitudes visited by man, but proceeding higher north, probably, than any other animal. Vast flocks of them are, every year, seen flying alternately north and south, at the highest northerly settlements. So numerous are these passengers over Hudson's Bay, that the inhabitants make it a business to shoot them in the fall, for a part of their winter's stock of provisions. Where they spend the summer, and on what they subsist in that region, has of course, not yet been discovered.

Some species of the Vulture tribe, are also said to be general inhabitants of the torrid and temperate regions.

Migrations of Birds.—A great proportion of the birds which inhabit the north temperate regions, in the summer, migrate into warmer climates before the approach of winter.

In the spring these tribes proceed to the north, where they rear their young, which, in autumn, are sufficiently strong to accompany their parents to their winter's residence at the south.

In no instance is the superintending care of Providence over the animal kingdom, more obvious than that exhibited in the migration of birds.

Each tribe come and go, at times best suited to their wants, habits, or convenience. Some rear two broods, and these appear as early in the spring, as their mode of living will allow. Those which subsist on insects, wait until the warmth of the season has hatched a supply of the peculiar kinds of which they partake. Others, which live on seeds and vegetables, also make their appearance at appropriate seasons.

What bird is said to inhabit all regions? What is the fact with respect to the migration of most birds which inhabit temperate regions?

The *Woodcock*, which rears two broods, and which lives on the larvæ of insects, found in the mud, appears in the early spring, nearly as soon as the frost will allow their long bills to pierce the ground, and continues with us, until the frost of autumn hardens the earth, and compels them to retire south in search of food.

The robbin, blackbird, swallow, and martin, in like manner, migrate north and south, with the seasons, observing severally, their times of coming and going, with wonderful exactness. But on this curious and fruitful subject, our limits will not allow us to dwell.

NUMBER, AND GEOGRAPHICAL DISTRIBUTION, OF INSECTS.

Insects are much the most numerous class of animated beings. They even greatly exceed the plants in the number of their species; and although naturalists in different parts of the world, have labored incessantly, and with the most boundless enthusiasm, in this department of nature, still it is doubtful whether one half of the Insects existing, are known.

According to Mr. Curtis, who appears to have taken the last "census" of British Insects, their number in that kingdom, now known, amounts to 12,500.

Linnæus estimated that there were four or five species of Insects for each species of phænogamous plants, and there are nearly 40,000 such plants contained in the catalogues of botanists. This, therefore, at the present time, taking the highest supposed number, would make that of Insects equal to about 200,000 species on the earth.

But there are, undoubtedly, thousands of plants still unknown, and were their numbers ascertained to be twice that now known, still it is more probable that the number of Insects are quintuple that number, than that they fall short of it.

The number of phænogamous plants, indigenous to Great Britain, is 1500, which, according to the highest

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How many insects did Linnæus estimate for each species of plant? Taking the number of insects and plants in England, and the number of plants known, as data, what is the number of insects on the earth?

Linnæan estimate, would give only 7,500 insects to that country, whereas, there is known to be there, at least 12,500, as stated above.

Now the phænogamous plants in Great Britain, being 1500, this gives more than eight insects to a plant; and there being already known, 40,000 such plants, according to these data, the number of Insects are at least 320,000, in the world.

Distribution of Insects.—Nearly all Insects depend on particular species of plants for subsistence; and so rigidly do some tribes adhere to this law, that if taken from the plant, on which they are found, and placed on any other, however near to it in affinity, they will rather starve than touch the new food on which they are placed. This is the case with most Caterpillars, and hence it is, as every one must have observed, that we find different species on different plants: one on the nettle, another on the parsnip, another on the cabbage, &c.

From these circumstances, it will be inferred, that the distribution of Insects must depend, more or less, on that of plants, and which we shall find to be the case.

The French naturalist, Latreille, in treating of the Geography of Insects, states, that all the species brought from the eastern parts of China, and Asia, whatever may be their latitude and temperature, are distinct from those of Europe and Africa.

The Insects of the United States, although they approach very closely to those of Europe, are yet distinguishable from them, by certain specific marks; and those found on different sides of the Andes, in the equatorial regions of South America, are said to present different species.

From these facts, we see that Insects, like plants, quadrupeds, and birds, are chiefly confined to certain limits, and that different countries, every where present different species.

What is said of the exclusive adherence of insects to particular species of plants? What is said of the different species of insects which inhabit different countries?

Migration of Insects.—Some species of Insects migrate from one country to another, in vast swarms, often at distant and irregular periods, while a very few species are said to be general inhabitants of the earth. Of the latter, is the Painted Lady Butterfly, (*Vanessa cardui*) which is said to be dispersed over Europe, Asia, Africa, and America, with scarcely a varying streak, to distinguish those of one country, from those of another.

A few years since, a vast swarm of these butterflies, forming a column from ten to fifteen feet broad, and in close order, traversed Switzerland from north to south, flying with great rapidity, and not turning from their course to avoid any obstacle. Their flight was observed through a considerable extent of country, but what migratory instinct directed them, and whence they came, and whither they went, was never ascertained.

In like manner, some thirty years ago, vast swarms of the Dragon Fly, (*Libellula*) known by the name of "devil's needle," traversed the sea coast of Connecticut. They came from the north, and pursued a southerly direction, and at times, during most of a day, were seen in dense streams as far as the eye could reach in both directions. Sometimes the air was literally filled with their numbers, forming clouds or bands, a yard or more broad, and which, from the time occupied in passing, must have been many leagues in length. The writer well remembers this phenomenon, but so far as he knows, it is the only instance of a similar migration of this insect.

Devastations caused by Locusts.—The migratory habits of this devouring Insect, are well known, and therefore details on this subject are needless. We shall, however, end the subject of the Geographical Distribution of Animals, by citing a few instances of the destruction of human life in consequence of the devastations of these Insects, in different countries.

Anciently, and in certain countries, the Locust was the greatest scourge which mankind was destined to en-

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What insect is said to be a general inhabitant of the earth? What is said of the migrations of insects?

dure, but more recently, we seldom hear of the occurrence of famine, as a consequence of their depredations.

Egypt, and other parts of Africa, as well as Spain, Italy, India, Germany, Arabia, Hungary, Poland, and many other countries, have, in their turn, suffered famine and death by these insects.

There are several species of the Locust, and we have therefore given a drawing of that which is chiefly concerned in the devastation about to be described. The

Fig. 24.

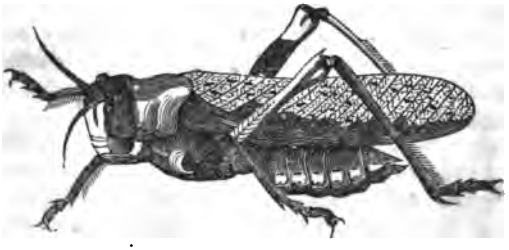

figure represents the size and form of the Insect. It is distinguished as the migratory Locust, (*Locusta migratoria*) and is a native of Eastern countries, but sometimes migrates to great distances.

It is not the Locust alone in the winged state, by which these devastations are committed, the larvæ, or caterpillar before the change, being equally as voracious as the Locust.

It appears from the Prophet Joel, that the devastations of this insect were known in the remotest times.

"A fire" says this Prophet, "devoureth before them, and behind them a flame burneth: the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them." "The sound of their wings is as the sound of chariots,—of many horses rushing to battle. Before their faces, the people shall be much pained, all faces shall gather blackness," &c.

This description answers admirably to the phenomena, known of the locusts as described by various authors.

So late as 1797, the traveller Mr. Barrow, was an

eye witness to the swarms of locusts which invaded Southern Africa. He states, that the whole surface of the ground, for an area of nearly two thousand square miles, was literally covered with them. The water of a broad river was scarcely visible, in consequence of the numbers which floated on its surface, and which were drowned in attempting to eat the reeds which grew along its shore.

Every green thing was as completely destroyed as if it had been burned over. They seemed, however, to have a choice of food, for when they came to a field of wheat or other grain. they would first mount up to the ear and pick out every kernel of grain, before they touched the leaves and stem. Their march was straight forward, and it was found impossible to turn them in another direction.

Having laid waste a great extent of country, as though a special providence had interfered, they were destroyed in a singular and summary manner. A tempestuous wind from the north-west, swept them into the sea, and such was the myriads destroyed in this way, that what the waves cast again upon the shore, formed a bank of three or four feet high, to the distance of nearly fifty miles. When putrefaction took place, the stench of this enormous mass was experienced, with the wind in that direction, to the distance of 150 miles. Great numbers of people perished by disease brought on by such an atmosphere, as well as by famine.

It is stated by authors, that in the year 591, an infinite army of locusts migrated from Africa into Italy, and after destroying every green vegetable to a great extent, were finally cast into the sea, where, with the pestilence from their decomposition, and the famine which they occasioned, nearly a million of men and animals perished.

St. Augustin records an account of a plague and famine from the same cause, which in the kingdom of Masinissa, in Africa, destroyed no less than 800,000 people.

In the Venitian territory, in 1478, more than 30,000 persons perished in consequence of the devastations and pestilence occasioned by these insects.

The same scourge, in a similar degree, has at different times afflicted France, Spain, Poland, Russia, and many other countries of the Old World.

This Insect, we believe, has never yet crossed the Atlantic, at least, in such numbers as to produce any considerable consequences. Nor is it probable that in those countries where the potatoe is, to any considerable degree, depended on as an article of food, that this dreadful scourge will ever again produce its former effects, since the vines of this vegetable may, to a great degree, be destroyed, without materially affecting the roots; whereas in those countries where the locust has produced famine, every vegetable, without exception, used as food, was destroyed.

ESTIMATED NUMBER OF ANIMAL SPECIES.

According to Temminck, the number of Mammiferous animals known, amounts to about 800 species.

Cuvier estimated the amount of known Fishes, at 6000 species.

The Quarterly Review estimates the ascertained species of Birds, at about 6000.

In Gmelin's 13th edition of Linnæus, the species of Worms are considered as amounting to about 4000, and those of Amphibious Animals to upwards of 2500.

The Insects, according to the view we have taken of the subject, cannot be less than 200,000 species.

We may, therefore, safely estimate the number of the species of animated beings on the earth as follows:

The Mammiferous animals being quadrupeds, with the exception of a few species, as the whale, we will place them all under this head.

Quadrupeds,	800	Fishes,	6,000
Birds,	6,000	Amphibia,	2,500
Insects,	200,000	Total,	215,300

What is said of the potatoe in preventing famine? What is the number of known and estimated species of animated beings.

GEOGRAPHICAL DISPERSION OF MAN.

It has been a favorite opinion of writers on the Physical History of Man, that his original birth-place was somewhere within or near the tropics, where he would, in the infancy of the arts, require but little protection from the elements, and where the natural fruits, and roots, which the earth produces, would abundantly supply him with food. And although at the present day, we cannot trace our original location with geographical accuracy, still there is no doubt that our race began in a temperate climate, as we know that the Creator has ever had us under his especial care, being the "noblest work of his hands."

We have no room to trace the progress of our species from "the hunter state," in which, it is supposed, we began, to our present elevation in knowledge, and in the arts of civilized life. Our progress, in these respects, has, on the whole, been constant; though there still exists a remarkable difference in the different varieties, in the grades of knowledge, and civilization to which they have attained. This difference, we might proceed to show, depends on climate, situation, fertility of the earth, population, national intercourse, and a variety of local causes, by which the minds, and dispositions of men are physically influenced.

At present, however, we are to speak of the means by which our race has become so widely distributed over the earth.

Taking it for granted, that Man had his beginning where his food was the spontaneous productions of the soil, it is plain, that, being endowed in a superior degree to other animals, with the faculty of invention, and the power of execution, he would soon see the necessity of not only cultivating the ground, as a means of more certain, and comfortable subsistence, but would also extend his range whenever his numbers became so great as not to find subsistence within their former limits.

The race, thus, in process of time, would be dispersed into the temperate zone, and the new difficulties there experienced of subsistence, and of protection from the

cold, and from wild animals, would bring forth new energies, and new inventions; for man, though naturally an indolent animal, has an instinctive love for personal comfort, which is not excelled by the most industrious species.

It is not probable that an animal so preeminently *omnivorous* as man, would long be contented with the fruits of the earth, and such fish as he could take from the rivers and lakes in his vicinity; and therefore we may conclude, that he soon began to prey upon the beasts of the field; at first upon the smaller animals, and afterwards, upon those which required the chase. This would lead him into the forests, and as the game became scarce, would impel small parties of unusual enterprise, to take up their residence at a distance, and thus extend the limits of the species.

We cannot follow out this beginning, and show how our race gradually extended itself into all climates and situations on the earth; nor is it necessary, since it will be seen at once, that the same motives which would induce man to cultivate the earth, and disperse in parties into the wilderness, would, by an extension of the same principle, urge him on to invent arms, and clothing, build houses, and form societies for his protection, and finally, to make laws for the regulation of such societies, and thus to form civilized communities.

How Islands became inhabited.—But it may be said, that this only explains the manner in which man might have extended his range over continuous continents; whereas we find that every island, and some of them at great distances from any continent, is still found peopled by the human race. Even the coral islands of the Pacific ocean, many of which are only sufficient to subsist a few families, are found to be inhabited; and if our race all sprang from the same continental pair, the inquiry naturally arises, whence, and in what manner, were these islands originally peopled?

Drifting of Canoes and Boats.—In order to account for the manner in which it is possible, that distant islands might have acquired inhabitants, we must refer to some

facts, furnished us by navigators, with respect to the distances which canoes have drifted, with people on board.

Captain Cook found, on the island of Wateoo, three people belonging to Otaheite, who had drifted there, in a canoe of small size, though the distance through the vast Pacific, was 550 miles.

Malte-Brun states, that in 1696, two canoes, carrying thirty persons, which had left Ancorso, were thrown, by contrary winds, on the island of Samar, one of the Philippines, at a distance of 800 miles.

In 1721, it is stated by the same authority, that two canoes, containing twenty-four persons, men, women, and children, were drifted from an island called Farroilep, to the island of Guaham, one of the Marians, a distance of 200 miles.

Captain Kotzebue, when investigating the Coral reefs off the Caroline Islands, became acquainted with a man named Kadu, who was a native of Ulea, an island 1500 miles distant, and from which he had been drifted in a sailing boat.

This man, with three of his countrymen, having left that Island in their boat, encountered a storm which drove them to sea, where they drifted about in various directions for *eight months*. Their reckoning of time was kept by making a knot in a cord for every new moon. Being expert fishermen, they subsisted entirely on the produce of the sea; and when it rained, they laid up as much fresh water as they could collect.

When these poor fellows had reached the Isles of Radack, which was the first inhabited land they made, every hope, and almost every feeling, had died within them. Their sail had long since been entirely destroyed, and being reduced almost to skeletons, they had no power to work their boat, which had, therefore, for months, been the sport of the winds and waves. When found, they lay in a state of insensibility, their boat dashing against the shore, but by the kindness of those into whose hands they fell, they soon recovered, and were restored to health.

Captain Beechey, in his late voyage to the Pacific, fell in with some natives of the Coral Islands, who, in a similar manner, had been carried to a great distance at

sea. They had embarked, to the number of 150 persons, in three double canoes, from Chain Island, which is situated about 300 miles to the eastward of Otaheite. In their voyage, they had been overtaken by the monsoon, which dispersed their canoes, and after drifting them far at sea, left them becalmed, so that, having consumed their provisions, many of their number perished for want. Two of the canoes were never heard of, but the other was drifted from one uninhabited island to another, at each of which they obtained some little provision, by which they were kept alive. At length, after having wandered to the distance of 600 miles, they were found, and carried home by Captain Beechey.

We see from these instances, in what manner the inhabitants of a continent, might involuntarily be transported to an island many hundreds of miles distant, and how, when one island is peopled, others might receive inhabitants.

With respect to subsistence, there is little difficulty, since it is well known that nearly all the islands of tropical climates contain the bread-fruit, cocoa-nut, and other fruits, on which the inhabitants to this day, in many instances, chiefly live.

PHYSICAL HISTORY OF MAN.

Man, the noblest inhabitant of the globe, is distinguished from all other animals, by his erect position—his commanding features—by the form of his head, feet, and hands—and above all, by his faculty to reason and invent, and his ability to execute.

Man is the only animal whose organization fits him to walk in the erect position, all others which take this position, do so by coercion, no animal with four limbs having ever been found in his native state walking upright. Several species, as the Orang Outang, are thus represented, but this is a deception. They may be made

How is man distinguished from other animals? Is any other animal but man formed for the erect position?

to stand erect for the painter, but this position is as painful and unnatural to them, as it is for Man to walk on all-fours.

Varieties of the Human Race.—Of Man, in the Natural History classification, there is only a single genus, and a single species; but there are several varieties, which have been formed by climate, and manner of living.

Some naturalists have designated four, and even five, such races, but not more than three varieties are sufficiently distinct to admit of a definite description.

These races are the *Caucasian*, or white; the *Mongolian*, or yellow; and the *Ethiopian*, or black.

The Caucasian, to which race we belong, is distinguished by the beauty of the oval outline of the head, the whiteness of the skin, the varying, ruddy complexion, and the color of the hair. To this race belong the Europeans, and their descendants in America. It also embraces the inhabitants of Western Asia, as far as the Himmaleh mountains, and includes the Turks and Persians.

The Mongolian race is known by his high cheek bones, flat visage, narrow and oblique eyes, straight black hair, scanty beard, and olive complexion.

To this variety belong the Chinese, Japanese, Coreans, and nearly all the hordes which are found north-east of Siberia.

The Ethiopian, or African race, is marked by a black complexion, crisped, or woolly hair, compressed cranium, flat nose, projecting lower jaw, thick lips, and protuberant heels.

This race is confined to the south of Mount Atlas.

Is there more than one genus of our species? What are the varieties of man? How is the Caucasian race distinguished? To which race do we belong? How is the Mongolian race distinguished? What are the principal nations belonging to this race? How are the Ethiopians marked?

The Caucasian race is so called, because tradition and the filiation of nations seem to refer its origin to the vicinity of that range of mountains, which stretches across from the Black, to the Caspian Sea, called the Caucasians. The various nations in the vicinity of that mountain, as the Georgians, and Circassians, are considered the most beautiful in person, of any on the earth.

It is by that great and venerable branch of the Caucasian stock, now inhabiting Europe, and of which branch we are a subdivision, that philosophy, the arts and sciences, agriculture and building, have been carried to their present state of perfection.

The Mongolians, especially the Chinese, and Japanese, have established great empires, and have carried a few of the arts to a considerable degree of perfection. But in the sciences of nature, and government, and in civilization, and invention, they are centuries behind the Caucasians.

Several branches of this race, as the Kalmucs, and other Tartar tribes, are still wandering shepherds, or live by war and plunder. They are mostly addicted to Buddism, or the religion of Fo.

The Ethiopians possess neither the arts nor sciences, properly so called, but have remained in the most complete state of barbarism, from the earliest times of history.

ORIGIN OF MAN.

Our origin from a single pair, as a historical fact, rests on the authority of Revelation. But such has been the scepticism of man, with respect to the divinity of the Scriptures, and such, in the course of ages, has become the difference in the varieties of our race, with respect to color and size, as well as in respect to moral and intellectual qualities, that many have doubted whether all could have had a common origin. And accordingly, it has been attempted to be shown, that the African and

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Whence comes the name of the Caucasian race? What is said of the acquirements of this race? What are the principal nations of the Mongolian race? What is said of the acquirements of this race? What is said of the origin of man?

European belonged to different stocks, and, therefore, to separate creations.

Recent authors have, however, shown most satisfactorily, that all the different varieties of Man can be accounted for, through the influence of climate and condition, and that it is not only unnecessary, but unphilosophical, to assign more than one creation for the origin of our species.

Instead of tracing this subject physiologically, we will here present some known facts with respect to the changes which climate, food, and situation, have produced on Man, and various other animals, and to those who have not particularly examined the subject, this will be the most satisfactory way of showing that he might have originally derived his existence from the same identical source, and still present all the varieties which exist.

Relation between the Geography and Colors of Men.—In the first place then, when we take a comprehensive view of the races of men as they are distributed over the earth, we shall see that there exists a relation between their colors and the climates in which they live. Thus the *black* races are situated within the torrid zone; while the *white* races are chiefly in the temperate and northern regions. Between these, are a *tawny* or middle-complexioned race, which inhabit the borders of both the temperate, and torrid zones.

It further appears, that the natives of highlands and mountains, are of a lighter complexion than others of the same tribe who inhabit the plains below. Thus the mountaineers of equatorial America, are lighter than those who inhabit the plains, and from the more elevated situation of that country, generally, the inhabitants are less dark than those of the same latitudes in India. The natives of Malabar, and the Hindoos of Deccan, are nearly black, and the same is the case with the inhabitants of Ceylon, and most of the Islands of the Indian Ocean. These people have none of them the

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What relations are pointed out between the present races of men and the climates in which they live?

crisped hair and thick lips of the African race, but the skins of some of them have nearly an Ethiopian darkness.

The Jews, a white race originally, and who have continued so in northern climates, have become, on the coast of Malabar, under the torrid sun of the East Indies, nearly as black as negroes; and the same is the case with the descendants of the Portuguese, who long since established a colony at Senegambia, in Africa.

Changes produced on Animals by Climate and Domestication.—One of the most widely distributed animals is the Dog, which, as we have already seen, has followed his master to every climate.

Now no naturalist denies, that all the varieties of this species which we see at the present day, came from the same original stock; and yet where is there a greater difference in the human race, either in color, size, or intellect, than there is between the noble Dog of St. Bernard, which by his strength and sagacity has saved the lives of many a traveller, from a snowy grave, and the degenerated Pug, which has no capacity beyond that of taking its daily food? The same difference exists between several other varieties, as the common Whelp and the Greyhound, the Pointer and the Mastiff.

It is true, that these changes have not been the result of climate only, but of culture, education, and feeding. But that climate alone, has also produced great changes in this species, is seen by contrasting the northern Dog, as that of Newfoundland, with his shaggy coat, and various colors, with that of Africa, with his black, naked skin, which are said to characterize the race generally, in that torrid region.

Changes nearly as great, have been produced on numerous other species of animals, by climate, situation, or condition.

Thus domestic Horses, as every one knows, are of various, and widely different colors, and yet the Wild Horses of South America, which were introduced there

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What is said of the changes produced in the Jews and Portuguese by climate? What is said of the origin and varieties of the dog species?

from Spain, less than two centuries ago, are all of one color, a chestnut, or bay-brown, the domestic ones in that country, still retaining their variety of shades.

Professor Blumenbach mentions many cases of a similar kind, which illustrate this subject. Thus the Swine of Piedmont, he states, are all black, while those of Bavaria are of a reddish brown. In Hungary the Oxen are of a grayish white; in Franconia they are red. In Guinea, the Dogs and Hens are as black as their owners; in other countries, these two races, we know, present almost every shade of color.

Many other similar instances might be adduced from writers, but these are sufficient to show what changes may be wrought on the lower orders of animals by climate, and other causes, and also, by a parity of reasoning, how similar causes, operating during a long sucession of ages, on the human species, might have produced all the changes, which are presented by the different races.

PHENOMENA OF THE ATMOSPHERE.

We have already, while giving a rapid sketch of the natural history of the earth, taken notice of the Pressure and Temperature of the Atmosphere.

But there are various, and important phenomena, in which the Atmosphere is concerned, which still remain to be described, and to which the attention of the student will now be directed. Among these are Rain, Hail, Wind, Waterspouts, Hurricanes, Lightning and Thunder, Dew, &c.

In the explanation of several of these subjects, we shall have to refer to the principles of Electricity, and therefore, a short treatise on that subject will first be given, and as Magnetism is a kindred science, we shall also explain its principles in the next article.

ELECTRICITY.

The earth is the great store-house of electricity, and consequently, our sketch of its Physical History would

not be complete, without a consideration of this subject.

Definition.—The word Electricity comes from the Greek *electron*, which signifies *amber*, probably because this substance was among the first in which electrical properties were observed.

Phenomena of Electricity.—When a piece of glass, amber, or resin, is rubbed with the dry hand, or with a piece of woollen cloth, or fur, the substance so rubbed being presented to small light bodies, as bits of paper, straw, or threads, these bodies will be seen to fly towards it, and for a time to adhere to its surface.

Substances capable of thus attracting others, are called *electrics*, and when rubbed, by which they acquire this power, are said to be *excited*.

Substances incapable of this excitation, are called *non-electrics*. All the metals, and a great variety of other substances, belong to this class.

The principal electrics are *amber*, *resin*, *sulphur*, *sealing-wax*, *glass*, the *precious stones*, the *fur of quadrupeds*, *baked wood*, and *very dry paper*.

The excited electric, having attracted the small, dry body to its surface, holds it there for a moment only, when the force which brought them into contact ceases, or operates in a contrary direction, and the light body is *repelled*, or thrown away from the before excited surface.

These phenomena constitute the basis of the science of Electricity.

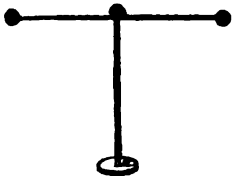
Electroscopes.—Various modes have been devised for detecting and exhibiting very minute quantities of Electricity, and the instruments constructed for this purpose, are called *Electroscopes*.

One of the most simple of these instruments is repre-

What is said to be the great store-house of electricity? Whence is the word Electricity derived? What are the phenomena of electricity? What are electrics? What are non-electrics? What are electroscopes?

sented by fig. 25. It consists of a light metallic needle, say of copper, terminated at each extremity by a small ball made of elder-pith, covered with gold leaf, and supported horizontally on a fine point.

Fig. 25.



A piece of sealing-wax or glass, being rubbed, and presented to one of the balls, will cause it to move, either towards, or from the the excited body.

Another form of the same instrument, consists of two pith balls suspended by silken strings to a glass handle, fig. 26. The necessity that the handle should be of glass, arises from its being a non-conductor, as will be explained hereafter.

Fig. 26.

On presenting an excited electric to the balls, they will approach it, and when in contact, will adhere to the electric for a moment, after which the balls will both be repelled, but will remain in contact with each other.

If, now, the electric be taken away, the balls will mutually repel each other, and will remain, for a short time, in the position represented by fig. 27. But if, while in this situation, one of them be touched with the finger, or a piece of metal, or with any other non-electric, the two balls will instantly attract each other, and will again come together, as in the first position.

Fig. 27.

These experiments prove, first, that when two bodies are in different electrical states, that is, when an excited electric is presented to the balls in their ordinary state, they mutually *attract* each other; and second, that when they are in the same electrical states, the two balls hav-

How is one of the most simple electroscopes constructed? Do bodies in the same electrical states, attract, or repel each other?

ing received portions of the electric fluid from the excited body, they mutually *repel* each other; and third, that when two bodies are electrified, and are in a mutual state of repulsion, they again *attract* each other, by depriving one of them of the electrical fluid, as by touching it with the finger.

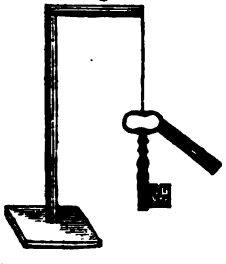
If one of the electrified balls be touched by an electric, as with a piece of sealing-wax, or glass, instead of with the finger, or a piece of metal, the two balls will not be effected thereby, but will continue to repel each other as before, their electrical states remaining the same.

Hence we learn, that some bodies, as the finger, and the metals, are *conductors* of electricity, while the electrics, as glass, and sealing wax, are *non-conductors* of the same.

In general, it may be stated, that all substances capable of electrical excitation, are also non-conductors, while non-electrics are conductors. Hence it appears that the capability of excitation, and conduction, are incompatible with each other, and therefore never reside in the same substance.

Insulation.—When a body is placed upon a non-conductor, it is said to be insulated. Thus, when a person sits upon a stool with glass legs, or stands on a cake of resin, or when a piece of metal is suspended by a silken thread, the electric fluid cannot pass from them, its retreat being cut off, and prevented by the non-conductors. In this insulated state, any of the conductors, as the metals are capable of retaining the electrical influence, when communicated to them by an excited electric, and of exhibiting electrical phenomena, in the same manner as the electrics themselves.

Fig. 28.



Thus, if a metallic body, as a

When the balls are in a state of repulsion, why do they attract each other when one is touched with the finger?

key, be suspended in the manner shown by fig. 28, and to the upper part there be presented an excited stick of sealing-wax, the lower part of the key will attract light bodies, in the same manner as though they were presented to the sealing-wax itself. This is easily explained; for the silk thread, with which the key is suspended being a non-conductor, prevents the escape of the electricity, while the key being a conductor, transmits the electrical influence from the excited electric, to every part of the surface.

Conductors.—The principal conductors of electricity, are, all the metals, water, the acids, ice, snow, flame, living animals and vegetables, smoke, steam, metallic salts, and the moist earth.

ELECTRICAL THEORIES.

Dr. Franklin's Theory.—In order to account satisfactorily for the facts and appearances which Electricity exhibits, it was supposed by Dr. Franklin, that the earth, air, animals, and finally all terrestrial things, were pervaded with the electrical influence, and that friction disturbed the equal distribution of this fluid, by causing an accumulation in one part of the electric, at the expense of that which was in the other. Thus, when one end of a stick of sealing-wax is excited, that end contains more than its ordinary quantity of electricity, while the other end contains less.

If, now, a conductor be brought near the excited body, this accumulation is imparted to it, and then the conductor would have more than its ordinary quantity, while the electric would be reduced to the same state it was before excitation. The conductor, therefore, becomes in what Dr. Franklin called the *positive* state.

On the contrary, if the conductor be connected with the opposite extremity of the excited electric, and which

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How do we learn that some bodies are conductors, and others non-conductors? What is meant by insulation? What are the principal electrical conductors? Explain Dr. Franklin's theory. What is the difference between the positive and negative states?

has less than its ordinary quantity, then the conductor imparts a portion of its natural quantity to it, and therefore, will contain less than ordinary. This he called the *negative* state.

Thus, according to Dr. Franklin, all electrical phenomena may be accounted for, by merely supposing it to be in a greater or less quantity than ordinary. Bodies containing a larger quantity than ordinary being *plus*, or positive; while those which contain less, are *minus*, or negative.

Du Fay's Theory.—Although the plus and minus theory would seem to account very satisfactorily for most of the phenomena which electricity presents, still there are certain facts to be mentioned, on which a different theory has been founded. Thus, when an excited tube of glass is made to touch a pith ball, then that ball will first attract, and afterwards repel, another pith ball, as already stated; and if a piece of sealing-wax be employed instead of the glass, precisely the same phenomena will be produced. But if a piece of excited glass, and another of wax, be made to touch two separate balls, they will attract each other, in the same manner as though only one ball had been touched with the excited glass, or wax; but will not repel each other, as happens in the former case.

From such phenomena, M. Du Fay concludes, that Electricity consists of two distinct fluids, which exist together in all bodies. These fluids, he supposes, have a mutual attraction, but that they are separated by the excitation of electrics, and when thus separated, and transferred to non-electrics, as the pith balls, their mutual attraction causes these balls to rush towards each other. The two kinds he calls *vitreous* and *resinous* electricity, the first being obtained from glass, and the other from wax, and other resinous substances. The vitreous answers to the positive, and the resinous to the negative states of Dr. Franklin.

Now, Dr. Franklin's theory is much the most simple

Which electrics of the two theories answer to each other? What is said of the simplicity and practical uses of the two theories?

and easily understood, and as it accounts equally well for nearly all electrical phenomena, we shall consider it the true theory.

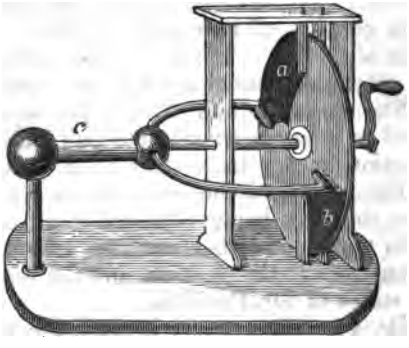
With respect to any practical, or scientific results, it makes no manner of difference which theory is adopted; since, if there are two kinds of electricity, their effects are precisely similar; nor can they be distinguished from the positive, and negative, except by some simple experiment like that above described.

ELECTRICAL MACHINES.

For the purpose of making electrical experiments on any considerable scale, machines are employed, by which large quantities of the fluid are set in motion. These machines are of various forms, but all consist of similar parts, namely,—1st, an *electric* substance, generally glass, of considerable size; 2nd, a *rubber*, by which the electricity is excited; 3d, a *prime conductor*, which collects and retains the electricity; and 4th, *machinery*, by which the body is turned, and experiments made.

Formerly, a cylinder of glass was employed, and made to revolve by a winch for this purpose. But more recently, a circular plate of the same substance has

Fig. 29.



What are the essential parts of an electrical machine?

been substituted for the cylinder, and which is considered an improvement in the machine.

This is represented by fig. 29, and consists of a circular plate of glass turning on an axis of wood, which passes through its centre.

The plate is rubbed by two cushions, *a* and *b*, fixed at opposite points of its circumference by means of elastic slips of wood, so as to press upon the glass with a force which is regulated by means of screws.

On the opposite side are two other cushions, not seen in the drawing, fixed in the same manner, so that the glass plate runs between them.

A brass prime conductor *c*, supported by a glass standard, is attached to the frame of the machine. On each side of the standard, and attached to it, are branches of the same metal, at the ends of which are pointed wires, nearly touching the glass plate, and from which the electric fluid is collected and conveyed to the conductor.

Mode of Action.—The manner in which this machine acts, is readily understood. The friction of the cushions against the glass plate produces a transfer of the electric fluid from the cushions to the glass, so that while the glass becomes positive, the cushions become negative. Meantime, the electricity which adheres to the surface of the glass, is attracted by the metallic points, and transferred to the prime conductor. This conductor being insultaed by a glass standard, the electric fluid is accumulated in quantities proportioned to the extent of its surface.

The Cushions must communicate with the Earth.—Were the whole machine insulated, the quantity of electricity obtained, would be only that which resided in the cushions, and their wooden connections; and therefore would soon be exhausted, and the machine would act without effect. To prevent this, and give a constant supply to the prime conductor, a communica-

Describe the mode in which the electrical machine acts. Why is it necessary that the cushions should communicate with the earth?

tion is made by means of a chain, from the cushions to the earth, which is the great reservoir of electricity.

For this purpose, however, it is only necessary to throw the chain on the floor, the communication to the earth being continued by the beams of the house.

Distribution of Electricity.

The quantity of electricity which any given body is capable of receiving, does not depend on its weight or bulk, but on the extent of its surface. Thus, a thin hollow globe, will retain twice as much as though it were solid, provided it has an aperture to the interior, for in this case the fluid accumulates on the inside, as well as on the exterior surface. For the same reason, a prime conductor made of pasteboard and covered with gold leaf, will receive precisely as much electricity as if it were made of the solid metal.

This shows that the fluid does not pervade the interior of solids, but only attaches itself to their surfaces.

It being the *principles* of Electricity, only, which it is our intention here to describe, we must refer the pupil to other treatises, for the methods of making electrical experiments.

Lightning and Electricity the same Agent.

The discovery of Dr. Franklin, that lightning is nothing more than immense electrical discharges from positive, to negative clouds through the air, constitutes the chief benefit which man has derived from this department of knowledge.

The similarity of lightning to electricity is not to be remarked in a few appearances only, says Mr. Cavallo, but is observable throughout all their numerous effects; and there is not a single phenomenon of the one, which may not be imitated by the other.

Lightning destroys edifices, animals, and trees—

What part of a body does electricity occupy? What is said of the quantity which a hollow ball will contain? How is it shown beyond a doubt, that lightning and electricity are identical?

Lightning goes through the best conductors in its way; and if its passage be obstructed, by electrics, or less perfect conductors, it rends, and disperses them in every direction.—Lightning burns combustible bodies;—it melts metals; and often disturbs the polarity of the magnet. All these effects, on a smaller scale, are produced by electricity.

But independently of the great similarity between the effects of lightning, and electricity, what proves their identity is, that the matter of lightning may be actually brought down from the clouds by means of insultated metallic rods, or electrical kites, and with which any known electrical experiments may be performed.

Protection of Buildings from the Effects of Lightning.

The invention of *Lightning Rods*, naturally followed the discovery of Dr. Franklin. The instrument itself hardly needs description, it being known to every one, that it consists of a metallic rod, reaching from some distance above the building, to the ground.

But the circumstances necessary for the due action of this instrument, and the consequent safety of a building, are not so obvious, and, indeed, not, in general, sufficiently understood. For, we shall see, directly, that many buildings are furnished with Lightning rods, which, in case of a shock from a passing cloud, would afford them not the least protection, though their inmates consider themselves perfectly safe, merely because a Lightning rod is attached to their dwelling.

Copper is a much better conductor of Electricity than iron, and, besides, is not so liable to rust, and therefore, on every account, is preferable to iron, for the purpose in question.

A Tube preferable to a Solid Rod.—As the electric fluid occupies the surfaces of bodies only, a tube of copper would not only much lessen the expense, but would conduct twice the quantity of the fluid, that a solid rod

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Which is the best conductor, copper, or iron? Why would a tube be more effectual than a rod?

of the same size would do, since it would present an interior, as well as an external surface, for the electrical current to occupy.

Safety depends on the Extent of the Surface.—The degree of safety will always depend on the extent of the conducting surface, for if the quantity of electricity be disproportioned to the surface of the rod, that is, greater than the rod can convey to the earth, a portion of it will undoubtedly pass through the building.

Termination of the Rod.—The upper termination of the rod should consist of several divisions ending in sharp points, composed of some metal which is not liable to oxidation, as silver, gold, or platina. The reason of this will be obvious from the fact, already stated, that points will draw the electric fluid from the prime conductor, without a shock. The greater the number of points, therefore, the less the danger, since these may deprive the cloud of its lightning in silence, while, without them, its accumulation would certainly give a shock.

Lightning Rods should not be Painted.—It is quite obvious, since electricity passes only over the surfaces of metallic conductors, and never through their substance, that lightning rods should not be painted, oil being absolutely a non-conductor, and the oxides of the metals, which give the color, bad conductors of electricity.

Inferences.—From the above principles, we may draw the following conclusions, with respect to Lightning Rods.

First.—That the most perfect Lightning rods to be obtained at a moderate expense, are made of copper tubes fastened together by screws, and left open, so as to conduct on the inner, as well as the outer surface.

How should the upper extremity of the rod terminate? Why should it terminate in points? What is said of painting lightning rods? Why should they not be painted? What are the four inferences drawn from the above principles?

Second.—That the larger the conducting surface, the more perfect the instrument, and the greater the safety.

Third.—That the upper extremity should terminate in many points, consisting of some metal which will not oxidate.

Fourth.—That the rod should never be painted.

Other circumstances to be considered.—So far as the conductor itself is concerned, the above are the chief points which claim attention; but there are other circumstances of equal importance to the safety of the building, and the lives of the inmates.

These are, first, that the rod should be continued, without interruption, from the top of the building to the ground; and, second, that it should descend to such a depth, as always to be in moist earth.

Not long since, a church was greatly injured, and several lives lost by lightning, because the rod did not reach the ground; it being probably understood by the constructor, that lightning, like a bullet, would follow the direction first given it, and therefore, that it would be a needless expense to continue the rod to the ground.

But unless the conductor be continued without interruption from the top of the building to the moist earth, or a pool of water, it cannot be depended on as a protector, though in all other respects, it may be quite perfect.

Water, next to the metels, is among the best conductors, while the dry earth is nearly a non-conductor.

On the approach of a thunder cloud, therefore, after a long drought, the conducting power of the rod would be greatly increased by wetting the ground through which it passes.

Perhaps, by such a little piece of attention, a house, or the lives of its inmates, might be saved.

Projection of the Rod above the Building.

It was formerly believed that a single rod, rising a

What is said of the uninterrupted continuation of the rod to the moist earth?

few feet above the roof, was a sufficient protection for any building of common size. But modern observations, and accidents, have proved, that a single rod only protects a circle around it, the radius of which is equal to twice its height above the building. Thus, if the conductor rises 10 feet, it will protect a circle whose circumference is 20 feet from the rod, or 40 feet in diameter.

The conductor ought therefore, to be erected as near the centre of the building as possible, for if stationed at one end, as is often the case, it affords only one half the protection it is capable of; the opposite end of the building, being as much in danger, as though Franklin had not made his grand discovery.

MAGNETISM.

Ancient writers inform us, that the word *Magnet* comes from the name of a shepherd, who, walking on Mount Ida, found a piece of *loadstone*, which had attached itself to the iron heel of his shoe, and that this was the first observation made on magnetic attraction.

Native Magnet.—The Loadstone, or Native Magnet, is a heavy ore of iron, found in various parts of the world.

Its color is a dark brown, or gray, with a metallic lustre.

Sometimes it is found in the form of crystals, but more commonly, in shapeless masses.

A piece of this substance, as it comes from the earth, being suspended by a string, will steadily turn one of its sides towards the north. From this simple observation, originated the first idea of magnetic polarity, and on this principle, is founded one of the most important, and useful of human sciences, though, at the present day, magnets are made without the aid of the loadstone.

What is the circle which a lightning rod of a given height will protect? What was the origin of magnetism? What is the native magnet? Is the loadstone used in making magnets at the present day, or not?

It was originally supposed, that no metal, except iron, was capable of receiving the magnetic influence, but it has since been found, that the two metals, *nickel*, and *cobalt*, may also be converted into magnets.

Definitions.—The *poles* of a magnet, are the two extremities of a magnetized bar, or needle, where the magnetic property appears to be concentrated. These are called the *north*, and *south* poles of the magnet.

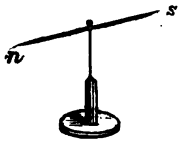
The tendency of a magnet, to assume the north and south position, is called its *polarity*.

The *axis* of a magnet, is a straight line, passing from one pole to the other.

The *equator* of a magnet is the centre of its axis, equi-distant from the two poles.

When a magnet is suspended by the centre, the two poles being of equal weight, it does not arrange itself horizontally, but inclines its north pole *n* downwards, while the south, *s*, rises above the horizon; this is called the *dip*, or *inclination* of the needle, fig. 30. This increases as the same needle is carried north, and diminishes as we approach the equator.

Fig. 30.



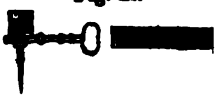
MAGNETIC ATTRACTION.

If either pole of a magnet be made to approach a steel needle, or small particles of iron, these will be attracted towards it, and will adhere to its surface, so that when the magnet is removed, they will be suspended, and carried away with it.

Fig. 31.

In this manner, scattered iron filings will be collected, and will adhere to the magnet, and to each other, as represented by fig. 31. The power of magnetic attraction is capable of being conveyed to a short distance through the air, from a magnet to a piece of iron, so that the iron while near the magnet will attract other iron.

Fig. 32.



Thus if a key, fig. 32, for instance, be held horizontally near a strong magnet, but not touching it, and if in this position, another small piece of iron, as a little nail, be applied to the other end of the key, the nail will be suspended from the key, and will remain there, until the magnet is withdrawn.

Fig. 33.

In this manner, a very powerful magnet will convey its influence through several pieces of iron, so that they will be suspended in contact with each other, the first only touching the magnet. This disposition is represented by fig. 33, where to the pole of the suspended magnet there is attached a key, and to this a smaller key, and to the small key a little nail. The power of the magnet suspending iron in this manner, is constantly increasing to a certain limit, it being able to suspend a few grains more to-day than it would bear yesterday, and so on for many days.

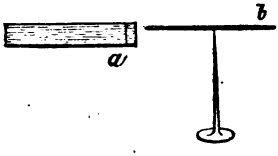
ATTRACTION AND REPULSION.

The leading properties of Magnetism are very simple, and easily understood. When the *north* pole of one magnet is presented to the *south* pole of another, they *attract* each other. This is called *magnetic attraction.* When the *two north*, or *two south* poles are brought near each other, a mutual recession takes place, and this is called *magnetic repulsion.* These facts are the foundation of all the varied and complex experiments, which philosophers detail on this subject.

What metals are capable of magnetism? What are the poles of a magnet? What is meant by polarity? What is the axis of a magnet? What is the equator of a magnet? What is meant by the dip, or inclination of the needle? Where is the dip increased or diminished? How s it shown that magnetism may be conveyed a short distance through ihe air? Explain what is meant by magnetic attraction and repulsion

Magnetic Induction.—When a bar of soft unmagnetized iron is placed near a strong magnet, and in a line with it, from north to south, fig. 34, the soft iron receives the magnetic influence, by what is termed *induction*, that is, without contact, and becomes itself a magnet, capable of attracting iron filings, and exhibiting polarity. When this is suspended on a pivot, its polarity will be found to correspond with that from which it was induced; that is, the north pole *a*, will produce the corresponding north pole *b*. Hence we see, that each pole of the magnet induces the opposite polarity in that end of the iron which is nearest it. Thus, had *a* been the south pole, instead of the north, *b* would have been south also.

Fig. 34.



Inductive polarity is not permanent, but ceases entirely on removing the piece of iron from the vicinity of the magnet. Thus when *a* is removed, *b* no longer points to the north.

ARTIFICIAL MAGNETS.

A red heat entirely destroys the polarity of a magnet, and hence the native magnet, when melted and forged, loses all its peculiar properties. Besides, the loadstone never occurs in a form which is required for useful purposes.

It is true, that the native magnet may serve to communicate its properties to iron, and thus perpetuate its powers for useful purposes. But this method, which was at first employed, has long since been superseded by the construction of artificial, without the least aid from native magnets.

Magnetism by Percussion.—For the construction of artificial magnets, various means have been proposed

What is meant by magnetism by induction? What effect does heat have on the polarity of a magnet? How is magnetism produced by percussion?

and employed, and among which, *percussion* is one of the most simple and efficacious.

This method is founded on the fact long since known, that on holding a bar of common iron in a vertical position, and giving it a few smart blows with a hammer on the upper end, that it becomes a magnet, and will attract iron, though only in a slight degree.

By placing the bar to be thus magnetized by the side of another bar of iron, in the same position, the effect of the percussion is greatly increased.

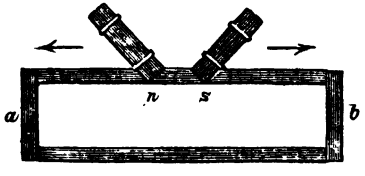
By such means, together with some peculiar management, which it is needless here to detail, bars of iron at length become fully magnetized.

When the manufacturer has thus prepared a number of bars, he is in possession of a powerful, and ready means, by which other magnets may be produced with little trouble, and in a short time.

Construction of Magnetic Needles.—When the operator is in possession of a number of magnetic bars, magnets of full power may be constructed in the following manner.

First, lay two steel bars, about six inches in length, half an inch wide, and the eighth of an inch in thickness, in a horizontal position, and connect their two ends by means of two shorter bars of soft iron, *a*, *b*, fig. 35.

Fig. 35.



Then taking two bundles of magnetic bars, with their poles in the same direction, as shown in the figure, begin the process as follows: Bring the north pole *n*, of one bundle, and the south pole *s*, of the two respective bundles together, over the middle of the horizontal steel bar, giving them such an inclination as is seen in the figure. Then separating from each other, make them

slide on the steel bar to each extremity, and repeat the operation many times on each side of the long bars severally. The steel bars, by this process, will finally become strongly magnetized, the marked ends of each forming the north pole.

The use of the cross bars of soft iron is to retain the magnetism in the steel ones, or prevent its escape during the operation.

THE COMPASS.

The *Compass*, is a general name for instruments designed to indicate the magnetic meridian. Of these, the most important are the *Mariner's Compass*, and the *Land*, or *Surveyor's Compass*. In these instruments, the magnetized steel, whatever its shape may be, is called the *needle*.

In the *Land Compass*, the needle is usually a small bar, six or eight inches long, with the north pole terminated by barbs, and suspended on a pivot, the points of compass being engraved on a plate of metal beneath.

In the *Mariner's Compass*, the needle is fixed to a round card, the circumference of which is divided into degrees, while an inner circle, described upon it, is marked with the 32 points of compass.

The face of a Mariner's Compass is represented by

Fig. 36.

fig. 36, with 16 of the 32 points of compass, marked upon it. These points need no description. The round

box containing the needle, and covered by a card, is suspended by means of two rings, or circles, called *gimbals*. These cross each other, and are so attached to the larger square box, as to allow the card and inner box to move in all directions, so that the needle and card retain their horizontal position notwithstanding the motion of the ship.

The importance of the Mariner's Compass, to the commerce of the world, is so great, that without it, the commodities of distant nations would cease to be transported, while by its use, the widest oceans are crossed in safety, and the productions of all climates are exchanged.

WIND.

Wind is a motion of the atmosphere, and is chiefly caused by a disturbance of its equilibrium by heat. Heated air being less dense than cold air, the former rises, while the latter descends.

If air, therefore, be heated in one place, while it remains cold in another, the equilibrium is destroyed, and while the former rises to the higher regions, the latter will rush in to take its place, and thus a current is formed, and the equilibrium restored.

This is well illustrated during the burning of buildings, for though it may be perfectly calm when the fire begins, and remain so every where else, still, in the vicinity of the combustion, there will be a strong current rushing from all directions, towards the flames, and thus an artificial Wind is created.

The use of chimneys is founded on the tendency of heated air to rise, since the smoke of burning fuel is carried from the fire-place, up their apertures, merely by such a current.

When, from natural causes, a large body of the atmosphere becomes suddenly heated, the colder portions rush, with greater or less velocity, to restore the equilibrium, and thus there is formed a gentle breeze, or a

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What is wind? What is the cause of wind? How does the burning of a house illustrate the manner in which wind is produced?

hurricane, depending on the rapidity with which the air moves.

The islands of the torrid zone are perpetual illustrations of the manner in which the equilibrium of the atmosphere is disturbed by heat, and the consequent currents of air which are produced. During the day, the wind blows in every direction from the sea, towards the centre of the island, because the land is more heated by the rays of the sun, than the water. During the night, on the contrary, when the influence of the sun's rays cease to act, the land becomes cooler than the sea, so that the morning breeze is from the land towards the water. Thus are formed the land and sea breezes, which are common to all the islands of hot climates, and which regularly alternate in opposite directions, in the morning and evening. Were it not for these currents, some islands, now delightful places of residence, would be nearly uninhabitable.

Trade Winds.—The heat of the torrid zone, causes an uninterrupted current of air to pass from each polar region, towards the equator, and as the atmosphere must necessarily participate in the motion of the earth, and as the velocity of the earth's circumference must increase from the poles to the equator, as already explained, so the velocity of the atmosphere, from west to east, must increase in proportion to its advance towards the equatorial regions.

Let us imagine, then, such a current of cold air rushing from the poles to the equator, to occupy the place vacated by the heated air, and throughout its progress, to be influenced by a constantly increasing rotary motion, from west to east, and it will be evident that, as two forces are acting on it, it cannot implicitly obey either, but must take an intermediate path, and in fact describe a curved line, the convexity of that line being turned towards the east.

The cause, and course of the trade winds, will easily be deduced from the above. In the Northern Hemi-

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How do you account for the variable winds of islands in hot climates? Explain the causes and direction of the trade winds?

sphere, there is a current of air from the north, towards the equator; but being impressed by a force tending to drive it eastward, that is, being under the influence of the earth's rotation, it takes an intermediate course, and a north-east wind is produced. In the Southern Hemisphere, there is a current from the south to the equator, but this being, also, under the influence of a force tending to drive it eastward, a south-east wind is produced.

Thus, within 30 degrees of the equator, in each hemisphere, constant Winds are blowing; that in the northern, from the *north-east*, and that in the southern, from the *south-east*, and from these causes, are produced the *Trade Winds*, so often mentioned by navigators.

Velocity of Wind.—The following table shows the different velocities of the air, in producing Winds, and their different effects, in the language of common experience.

Velocity. Miles per hour.	
1	Hardly perceptible.
2, 3	Just perceptible.
4, 5	Gentle, pleasant wind.
10, 15	Pleasant brisk gale.
20, 25	Very brisk.
30, 35	High wind.
40, 45	Very high wind.
50	A storm, or tempest.
60	A great storm.
80	A hurricane.
100	A huricane that tears up trees by the roots, &c.

There is much difference in the effects of Winds, depending on the presence, or absence, of rain. If the

rain falls in great quantities, a much less velocity of the air is required to give the same destructive effects, since the force of the Wind is greatly increased by the momentum of the water.

WATER-SPOUTS.

Among the most interesting, and perplexing phenomena, in which the atmosphere is concerned, are Water-spouts. Although much has been written on this subject, and many theories offered to account for their production, still their cause has not been satisfactorily explained. Some have supposed that they depended on the mechanical action of whirlwinds, while others attribute them to the agency of electricity.

That they cannot be caused by the mechanical action of the air alone, is proved by the known fact, that the weight of the atmosphere, acting upon a perfect vacuum, is only equal to that of a column of water 34 feet high, while Water-spouts have been seen several hundred feet, and in one instance more than 1000 feet in height. It is certain, that in most instances, these wonderful exhibitions are attended with the development of electricity, but in what manner that agent could act, to produce such an effect, it is not easy to explain.

Phenomena of Water-spouts.—The most common appearance of a Water-spout, is thus described. A low, rainy-looking cloud, of circumscribed dimensions, first appears, and under which, the sea becomes suddenly agitated. The waves thus disturbed, in a few minutes, appear to dissolve into vapor, which then rises in a spiral line, towards the cloud—at the same moment that this column rises from the sea, another is seen descending in an oblique direction, from the over-hanging cloud, which unites with the former; and the united column, though frequently several hundred feet broad at the base, seldom presents a greater diameter than two or three feet, throughout the greater part of its length.

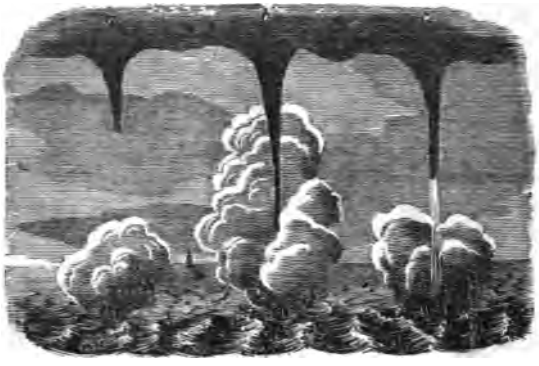
What is said of the cause of water-spouts? What are the phenomena of water-spouts?

Mr. Maxwell, who saw several of these fearful spectacles, on the coast of India, says, that the vapor, or fog, proceeding from the sea, was of the same color, as the spout, and resembled the smoke of a steam engine. The surface of the water, under the spout, during the whole time, was in a state of violent agitation, and a noise was heard, like that of a distant water-fall.

The same author had opportunities of witnessing these phenomena, at numerous and different times, and has given the adjoining sketch of their progress and termination.

At their first formation, the appearance is that of an inverted conical tube descending from the black cloud,

Fig. 37.



as represented at *a*, fig. 37. This is seen before any disturbance of the sea is observed. The black cloud continuing to descend, the sea becomes agitated, and a smoke-like appearance rises from the surface, until they join, as shown at *b*, forming a perfect column, which remains entire, for a few minutes only.

When the spout begins to break, or disperse, the black cloud draws itself up, and a thin transparent tube continues united to the cloud that rose from the sea, as shown at *c*. This, at last, being broken, the phenomenon disappears. The whole exhibition does not generally last more than three or four minutes.

Captain Napier's Account.—The Honorable Captain Napier, of the British Navy, states that, being in latitude about 30°, an extraordinary sort of whirlwind was seen to form, about three cables length distant. It carried the water up along with it in a cylindrical form, in diamter, to appearance, like that of a water-butt, gradually rising in height, increasing in bulk, and advancing in a southerly direction, and when at the distance of a mile from the ship, it continued stationary for several minutes, boiling and foaming at the base, and discharging an immense column of water, with a rushing, or hissing noise, into the overhanging clouds, turning itself with a quick, spiral motion, constantly bending, and straightening, according as it was affected by the variable winds, which now prevailed alternately from all points of compass.

It next returned to the northward, in direct opposition to the wind, and right upon the ship's starboard beam, whose course was altered to the east, in hopes of letting it pass astern. Its approach, however, was so rapid, that we were obliged to resort to the usual expedient of a broadside, for the purpose of averting any danger, that might be apprehended; when, after firing several shots, and one in particular having passed right through it, at the distance of one third of its height from the base, it appeared for a moment, as if cut horizontally into two parts, the divisions waving to and fro, in different directions, as agitated by opposite winds, till they again joined for a time, and at last were dissipated in an immense dark cloud, and shower of rain.

At the time of its being separated by the effect of the shot, or, more probably, by the agitation occasioned in the air by the discharge of several guns, its base was considerably within half a mile of the ship, covering a portion of the surface of the water, about 300 feet in diameter, from one extreme circumference of ebullition to the other; and the neck of the cloud into which it discharged itself appeared to have an altitude of 40 degrees, by the quadrant, while the cloud itself extended over head, and all around to a very considerable distance.

Now allowing from the ship, a base of about one third of a nautical mile, or say 2050 feet, and an angle of 40° to the top of the neck, we have then, for the perpendicular

height of the spout, about 1720 feet, or very nearly the third of a mile.

Capt. Napier's calculation of the height of this Water-spout, if within the hundredth part of the truth, entirely destroys the foundation of any theory based on the supposition that Water-spouts are caused by whirlwinds, for the reason already assigned.

RAIN.

Rain is the vapor, concentrated into the form of drops, which the atmosphere had before absorbed and elevated from the earth and sea.

The atmosphere, in the process of absorption, takes up only the pure water, rejecting equally the salt of the sea, and the impurities with which the fluid happens to be mixed on the land. The process of absorption, therefore, in this respect, is analogous to that of distillation.

But the natural process, is by far more select, and purifying in its operation, than the artificial one; for there are many substances with which water is mixed, from which we cannot separate it by distillation, whereas the atmosphere at once selects out only the aqueous particles from among the most impure, or putrid masses.

Cause of Rain.—It is universally agreed by meteorologists, that Rain is in some way produced by the condensation of the vapor, drawn into the atmosphere by evaporation. But the question arises, why does the vapor separate from the atmosphere, and fall down in drops? At first thought, the answer might appear obvious, since we know that condensation by cold, in many cases at least, forces the atmosphere to deposite its moisture. Thus steam, is instantly converted into water, by cooling. But it often happens that the Rain falls very abundantly during the warmest weather, and then again it begins to rain after the weather has been cold for several days, whereas did the rain depend merely on

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How high was Capt. Napier's water-spout? What is rain? Whence does the atmosphere obtain its moisture? What is the cause of rain?

condensation by cold, it ought to have begun, when the cold first commenced.

We must, however, conclude, from all the phenomena observed, that the Rain does depend on the condensation of the air in the higher regions, however little the change of temperature there, may effect the lower portion of the atmosphere.

Dr. Hutton, whose explanation of the cause of Rain, has been generally adopted, supposed it to depend on the difference of temperature in two intermingling clouds.

Rain, according to this theory, results from the union of extensive atmospheric strata, of different temperatures, charged with moisture. It is well known, that the higher the temperature of the atmosphere, the greater the proportion of moisture is it capable of retaining. Therefore supposing that a stratum of air is saturated with moisture, then if the temperature be diminished, it will be incapable of retaining the whole, and a portion will be condensed into rain. But if the temperature be raised, it will become capable of retaining more than before.

Let us then suppose, that two saturated masses of air, having unequal temperatures, and consequently containing different portions of vapor, meet each other and intermingle; then, as heat always finds an equilibrium, a mean temperature in the two strata will be produced, which, therefore, must be lower than that of one of the masses before contact: therefore a quantity of moisture, in proportion to the diminution of temperature in the warmest stratum of air, must be deposited, and thus Rain produced.

There are several objections to this theory, but on the whole, perhaps it explains the facts as well as any that has been offered.

Quantity of Rain in different parts of the Earth.—Under equal circumstances, the largest quantity of Rain falls at, or near the equator, and progressively diminishes towards the poles.

What is the proportion between the temperature of the atmosphere and the quantity of vapor it is capable of containing? When two saturated clouds of different temperatures meet, why is rain the consequence? Where does the greatest and least quantities of rain fall?

Baron Humboldt has given the following table as the result of his observations on the quantity of Rain which falls in different latitudes.

Latitude.	Mean annual depth of Rain.
0°	96 inches.
19	80 "
45	29 "
69	17 "

But although we speak of a relation between the latitude of a place, and the quantity of Rain that falls there, it must not be supposed that there is any constant average throughout any given parallel. Local causes interfere to prevent such a result. A less quantity of Rain falls upon the sea, than upon the land, there being on the sea no elevations around which the clouds are attracted.

Mountainous Countries most Humid.—Under equal circumstances, that is, at equal distances from the equator, mountainous countries are more humid than plains. This arises from the attraction which mountains exert on the clouds. Thus at Keswick, and Kendal, in England, both situated on the Cumberland mountains, the annual fall of Rain is 67, and 59 inches, respectively, while the average quantities, at places situated on the common level of the country, is no more than 24 inches.

The same fact is true of other countries similarly situated. Thus the quantity of water which falls on the Alps, is estimated at 100 inches per year, while in the valley of Lombardy, it does not exceed 35 inches.

Monsoons.—The Monsoons are periodical winds, attended, in certain seasons of the year, by storms of rain, in tropical climates.

In India, the rainy season commences with the southwest Monsoon, and reaches to Africa, and the Malay peninsula, deluging all the intermediate countries, during

How do mountains effect the humidity of a country? What are the Monsoons? How long do the Monsoons of India last?

four months in the year, but at other times, no Rain falls in these regions.

In South India, the Monsoon commences about the beginning of June, its approach being announced by vast masses of clouds, which arise from the Indian Ocean. These gather thickness and darkness for a day or two, when the rain commences with a tremendous thunder storm, of which, those who never witnessed such phenomena, can have no conception. The lightning and thunder are incessant, flashing and rolling, in one direction or another, without a moment's interval, for many hours. At length, the thunder ceases, and then nothing is heard but the pouring rain, and the rush of waters in the rising streams.

This continues for several days and nights, after which the sky clears, and the sun shows the face of nature changed, as if by enchantment. Before the rain, the fields were parched, and except in the beds of the rivers, many of whose waters had ceased to flow, scarce a blade of vegetation was to be seen. Not a cloud, before the storm, is seen for months, the clear sun pouring down his rays from above, while streams of heat were sent up night and day, from the burning earth. All nature appeared drooping and debilitated, under such a temperature.

But when the violence of the commencing Monsoon has subsided, the whole earth is seen covered with the most luxuriant verdure; the rivers are full and flowing; the air pure and delicious; the sky variegated with clouds; the beasts of the field no longer seek the thickets for protection, but are seen cropping the new verdure, and man, casting away his lassitude, becomes a new creature.

From this time, the rain falls at intervals, for about a month, when it again comes on with great violence, and reaches its height sometime in July, after which, it gradually subsides, and entirely ceases in September, with a great thunder storm, as it commenced.

Does it rain at other times in that country, or not?

Average number of rainy days in different latitudes. Although, as we have seen, the quantity of rain which falls, is much the greatest at the equator, and diminishes towards the poles, still, the number of rainy days are in the inverse order, being greatest towards the poles, and least towards the equator.

A French writer has estimated, that from north latitude 12° to 43°, the mean annual number of rainy days, is 78; from 43° to 46°, the mean number is 103; from 46° to 50°, the mean number is 134; and from 51° to 60°, 161.

Great Storms of Rain.—There is no subject on which we are so apt to be mistaken, as that of the weather. If an unusual season happens, the people generally consider that none like it has ever been experienced before, and if a great rain or snow storm occurs, it is believed that the quantity is unprecedented. On this account, it is proper to record, and describe unusual facts of this sort.

In England and Scotland, the number of rainy days during the year, may commonly be from 80 to 120. But in the years 553, and 918, it rained in Scotland continually, for five months.

In England, in the year 1338, from July to Christmas, there was not a single day and night without rain. In September, 1752, there was a rain storm in Wales, which destroyed 10,000 sheep, and a great number of other animals.

In the Island of Cuba, in 1791, there was a rain in the month of June, during which, such immense torrents flowed from the high, to the low lands, as to destroy 300 people, and nearly 12,000 animals of various kinds.

Storm of Catskill, in 1819.—The town of Catskill is situated on the west side of the North River, about 30 miles below Albany, in the State of New York, and 120 north from the latter named city.

Mr. Benjamin W. Dwight, has given a particular ac-

Where does the greatest quantity of rain fall? Where is the greatest number of rainy days?

count of this storm, in Silliman's Journal for 1821, and from which the following account is extracted.

About half past 3 o'clock, on the 26th of July, three distinct clouds, "dense and black," arose in the southeast, in quick succession, and a smart shower followed, when the rain ceased for a time. But towards 6 o'clock, another dense cloud arose from the southwest, and at about the same time, another still, rose *up* rapidly, from the northeast.

At this instant, the rain again commenced, and in a short time became so thick, that trees and buildings could not be discerned, even at the distance of a few yards.

After the meeting of the clouds, the wind blew at short periods, from almost every point of the compass, and the lightning and thunder became appalling: meantime the rain descended at times, not in drops, but in streams, or sheets.

Sometime after the clouds met, several persons saw, at intervals, when the rain was less abundant, a waterspout rising up from the river, having a broad base, and conical top, meeting the cloud in the usual manner. Two other water-spouts were also observed about a mile up the river, rising in the same manner.

The rain extended with equal violence, from three to eight miles distant from Catskill, in different directions. Over a considerable part of this tract, Mr. Dwight estimated, from facts which came to his knowledge, that the water which fell during the storm, was from 15 to 18 inches in depth. At one place, a tub 16 inches deep, was filled, and the water overrun the top. At another, an empty barrel was filled to the depth of 18 inches. The largest portion of this quantity fell *within half an hour*, namely, from a quarter before 6, to a quarter after 6, during which time, it was estimated that the amount exceeded 12 inches on a level.

The effects of this storm were not so disastrous as might have been anticipated, especially on human life, only a single person having perished, so far as was known, in consequence. It, however, produced large chasms in the earth, in various places. In the neighbor-

hood of Madison, a village situated a few miles from Catskill, there is a mountain several hundred feet high, at one extremity of which, there is a ledge of rocks, forming a perpendicular declivity of about 30 feet. The water accumulating at this place, formed a cataract over the precipice, and in its course, uprooted all the trees to the distance of several hundred feet, and carrying away the soil to the extent of two acres, and to the depth of from six to ten feet. No water had before ran along this place.

We give the above, only as a single example of similar effects which were produced in eight or ten different places. In some cases, huge rocks were moved from their beds, weighing from six to ten tons, and with smaller ones, heaped up in piles fifteen feet high.

The whole amount of damages done by this storm, was estimated at 50,000 dollars.

HAIL.

Hail consists merely of the frozen drops of rain; but why frozen water falling from the sky, should sometimes be in the form of round balls, and at other times, in the form of white flakes, it is no easy matter to determine.

Hail most commonly falls during the hottest seasons, and the clouds from which it descends, usually have a fearfully black, and threatening aspect. Were the hail stones always round, and regular in appearance, and of moderate size, we might account for their formation, by supposing the sudden production of a cold stratum of air, through which the drops of rain in their passage become ice, just as the globules of melted lead in their passage from a height, become converted into shot. But we shall see directly, that this supposition, even though we could account for the production of the cold stratum, does not explain the phenomena, since large blocks, or masses of ice, of almost every shape, sometimes fall from the atmosphere.

The celebrated Volta, proposed to account for the formation of hail, by supposing two horizontal strata of clouds near each other, in different electrical states, and

between which, the drops of water oscillate, as pith balls do between two metallic discs. (*See the author's Nat. Philosophy, p.* 283.) But this appears to be rather a *mystification*, than a solution of the subject, since, were the clouds in opposite electrical states, and near each other, they would rush together, and an equilibrium of electricity would instantly be formed, and besides, this theory does not account for the cold by which hail is formed during the warmest seasons. On the whole, the phenomena which this subject presents, has never yet been satisfactorily explained, though it has exercised the minds of philosophers in all ages. That electricity has some agency in the formation of hail, may be inferred from the universal fact, that all great storms of this sort are attended with lightning and thunder, and the electrometer, before the approach of such a storm, is always in a state of agitation, indicating an unusual development of electricity.

Hail Storms.—Hail storms are often, but not always, attended by high winds, and sometimes by hurricanes. When this is the case, their destructive effects are greatly increased.

In some countries, and especially in Spain and France, these storms are often the occasion of great calamities, sometimes entirely destroying the hopes of the husbandman, by cutting in pieces his crops, and killing his cattle.

Mr. Stewart gives an account of a hail storm, which some British troops encountered in the Pyrenees, in 1813, and to which he was an eye and ear witness.

The troops were on the march, in order to intercept Marshal Soult in his passage over the mountain. The storm lasted about twenty minutes, and the writer says, created much more alarm in the army, than the approaching contest. The hail stones gradually increased in size, from that of a bean, to that of a hen's egg. Fortunately the troops had their backs to the storm, else many of them must have lost their eyes. The rattling of the hail stones on the tin kettles and canteens of the soldiers, and the noise produced by their increasing size,

caused great alarm, even among those who were in the daily habit of exposing their lives to the dangers of war.

Enormous Hail Stones.—In 1819, July 4th, there happened a hail storm in the south of France, during which, there fell masses of ice 15 inches in circumference.

In 1697, April 29th, a black cloud passed over Lancashire and Cheshire, in England, which threw down hail stones of half a pound in weight. This storm was 60 miles in length, and 2 in breadth. In the same year, another storm of the same kind, passed over Hertfordshire, during which, there fell hail stones 14 inches in circumference, and by which several persons, and a great number of cattle, were killed.

In Italy, in 1210, there fell a shower of hail stones of such enormous sizes, that some of them are recorded to have weighed *an hundred pounds.* These masses were of a bluish color, and the air was filled with a sulphureous smell at the time.

SNOW.

Snow consists of water formed into crystals, in the atmosphere.

Snow is evidently formed under different atmospherical circumstances from that of hail; but in what this difference consists, it is not easy to determine. Hail falls during the hot season, but snow only during the cold. Sometimes the snow is in the form of little round white balls, but more commonly in flakes, which, on examination with the microscope, are found to consist of minute aggregated crystals, forming beautiful figures of various, but regular shapes.

The whiteness of snow is caused by the minute particles of which it is composed, and by which the white rays of light only are reflected. Solid ice is transparent, and colorless, but if it be broken into small pieces, and ground to powder, it instantly becomes opaque, and of a white color. Many other substances, as a slate pencil, and glass become white by minute division.

Snow always contains a large quantity of air, and air being a bad conductor of heat, the snow partakes of the same property, and hence it is, that in cold countries, the snow protects the ground from the intense cold of the atmosphere. Thus, in Siberia, where the temperature of the air is 40 degrees below zero, that of the earth under the snow, is scarcely below the freezing point, and thus is vegetation protected from a frost, which, in many instances, would be fatal to it.

Notices of Remarkable Snow Storms and Winters, in the United States.—The winter of 1835–6, has been considered for length, and the depth of snow, equal to any which has happened in this country since its first settlement. It was, undoubtedly, the most severe winter since that of 1779–80, but before that time, there were several winters in which there fell a much greater quantity of snow, though we cannot compare their temperatures, no thermometrical records having been published by the early settlers.

"*Great Snow*" *of February*, 1717.—It began to snow about noon, on the 20th of February, and continued snowing until the 22d. On the 18th of the same month, it also snowed, so that on the 26th of February, the "Boston News-Letter," published at the time, states that the snow in the streets of that town, was about *six feet deep.*

In Dr. Holmes' "History of Cambridge," it is stated that the funeral of Mr. Brattle (Minister of Cambridge), was attended on the 20th February, of that year, and that the day was rendered memorable by the "Great Snow," which detained many of the people of Boston, and other places, at Cambridge, for several days.

In some places, the drifts, according to the accounts, were 25 feet deep.

In the "Boston News-Letter," of March 25th, it is stated, that "the mail went on snow-shoes, and that the carrier was 9 days in reaching Portsmouth, and 8 in returning:—17 days in going 120 miles. He (the mail carrier), says, that in the woods, the snow is five

feet deep, and in some places, between 6 and 14 feet deep."

Concerning this snow, John Winthrop, of New London, says, in a letter to Cotton Mather,—"The storm continued so long and severe, that multitudes of all sorts of creatures, perished in the snow-drifts. We lost at the Island and farms, above 1100 sheep, besides some cattle and horses interred in the snow. And it is very strange, that 28 days after the storm, the tenants on Fisher's Island, pulling the ruins of 100 sheep out of one snow-bank in a valley (where the snow had drifted over them 16 feet), found two of them alive, in the drift, which had lain on them all that time, and kept themselves alive by eating the wool off the others, that lay dead by them. As soon as they were taken out of the drift, they shed their own fleeces; and are now alive and fat." This letter is dated Sept. 12th, 1717.

Winter of 1740–41.—It is stated on various authorities, that this winter was more severe than any which had occurred since that of 1717.

One writer at the time, says, "we hear from Stratford, in Conn., that the Sound is frozen over, so that people ride every day from thence to Long Island, which is 3 leagues across, and which was never known before." Another says, there were that winter, 30 distinct settled snow storms.

Another writer says, that the rivers were frozen over in October,—that the snow began to fall Thanksgiving day, Nov. 13th, and that on the 4th of April, it still covered the fences.

There is a certificate, that on the 1st of April, several persons with a heavy horse, crossed the Connecticut river from Northampton to Hadley, on the ice. They say, "We suppose the like has never been known in any age."

Winter of 1779–80.—Aged people speak of this winter as one of extraordinary severity. The depth of the snow was so great, that most of the roads in New England, were for many weeks, nearly impassable,

there being little or no communication from one town to another, except by means of snow-shoes. It is stated, both by the records of the time, and witnesses now living, that so steady and severe was the cold in Massachusetts and Connecticut, that for six weeks, the snow did not melt on the roofs of the houses, so as to make the eaves drop.

With respect to this winter, Dr. Noah Webster states, that the first snow storm occurred about the 25th of November, and that subsequent falls, raised it to the height of three or four feet. The Sound between Long Island and the main, was nearly all covered with ice between New York and Staten Island. Almost all the birds perished; here and there, only a solitary warbler was heard the next summer.

It appears from thermometrical observations made at Hartford, in 1780, at sun-rise, that on January 2d, the mercury was 7° below zero. Jan. 19th, 13° below—30th, 15° below, and Feb. 4th, 15° below. These were the coldest days of that month.

From a register kept by President Stiles, of Yale College, it appears that the two coldest days of that winter, were January 23d, when the mercury was 3½°, and January 29th, when it was 1° below zero. In February, the coldest day was 6° above.

Winter of 1784.—It appears from the records of temperature kept at Hartford, Conn. as given by Dr. Webster, that the February of that winter was much colder than the same month in 1780. It will be remembered that — means below, and + above zero.

Feb. 10	-	- — 19°	Feb. 14	-	— 20°
" 11	-	- — 12	" 15	-	— 12
" 12	-	- — 13	" 16	-	— 16
" 13	-	- — 19	" 17	-	— 16

This, Dr. Webster says, is the most extraordinary instance of continued and intense cold, he has ever known.

Winter of 1798–9.—This winter set in seriously,

early in November, and the Boston Chronicle says, that the mail sleigh ran from that city to Walpole, in New Hampshire, successively for 18 weeks.

During that winter, it is said that the ice obstructed the navigation of the Northern Seas in a very unusual manner—that many men and cattle perished in Europe by the cold, and that the river Thames was frozen over, and the roads in many parts of England were rendered impassable by the snow drifts.

Winter of 1835–6.—So far as can be ascertained by the thermometer, the year 1835—6, was the coldest of which we have any account, since the settlement of the New World; but it must not be forgotten there are no records of the temperature before 1780, during which, the thermometer never sank below —15°, and only twice so low.

The winter of 1784, was the coldest on record before 1835, as shown above, the thermometer at Hartford being twice down to —19° in the month of February, and once —20.

During the winter of 1835–6, there were several weeks in which the temperature at Hartford was a great proportion of the time down to zero, and several times it fell as low as —27 and —28, and even to —30°. At Dover, New Hampshire, it fell to—28, and at Concord —32, on the 4th of January.

The first snow of any consequence, fell on the 23d of November, and from that time to the end of March, the sleighing continued in all the New England States.

The Northampton (Mass.) Courier, says, last Sunday, April 3d, was the 20th Sabbath on which people have ridden to meeting in sleighs.

We here subjoin a highly valuable table, the result of 43 years observations of the venerable Dr. Holyoke, of Salem, Mass. and by which it will be seen that during the period from 1786 to 1828, there was only a single instance where the mercury fell to —13, which was on the 25th of January, 1821.

In reading this table, it will be recollected as formerly explained, that the sign — means below zero, and +, above it.

ABSTRACT OF DR. HOLYOKE'S OBSERVATIONS.

Table showing the number of days in which the Thermometer fell to zero, or below, in the different months, and in each year, the hottest and the coldest days in each year, and the Mean Annual Heat of each Year, from 1776, *to* 1828, 43 *years, according to Dr. Holyoke's Observations at Salem, Mass.*—From the American Almanac, of 1837.

Yrs.	Jan.	Feb.	Dec.	Mar	Yr.	Coldest Days.			Hottest Days.		Mean Ann'l Heat.
1786	3	0	1	0	4	—11	Jan.	17	93	June 4	48.53
1787	1	3	0	0	4	—5,	"	19	91	July 8	47.88
1788	2	2	2	0	6	—4,	Dec.	4	93	" 12	47.67
1789	0	3	0	0	3	—2,	Feb.	2	94	" 24	47.68
1790	0	2	3	0	5	—8,	Dec.	19	94	June 17	46.43
1791	1	0	0	0	1	0,	Jan.	22	96.5	July 13	48.96
1792	3	0	0	0	3	—11,	"	23	95.5	" 19	48.44
1793	0	0	0	0	0	+0.5,	Dec.	26	96.4	" 5	50.96
1794	0	0	0	0	0	+4,	March	4	93	" 18	50.76
1795	0	0	0	0	0	+1.5,	Feb.	26	95	Aug. 7	50.17
1796	0	0	2	0	2	—5.5,	Dec.	24	93.5	" 29	48.67
1797	4	0	2	0	6	—10.5,	Jan.	8	97	July 22	48.13
1798	0	1	0	0	1	—2,	Feb.	8	99	Jy. 2, Aug. 9	49.47
1799	1	0	0	1	2	—8,	Jan.	5	94	July 5	48.29
1800	2	0	0	0	2	—2,	"	29	100	" 31	49.98
1801	2	0	0	0	2	0,	"	3	96	Aug. 19	50.43
1802	0	2	1	0	3	—3,	Feb.	23	94	" 1	50.79
1803	0	0	0	0	0	+4,	Jan.	4	97	July 9	50.24
1804	0	0	1	0	1	—1,	Dec.	14	95	" 30	48.32
1805	1	0	0	0	1	—3,	Jan.	4	99.5	" 13	50.79
1806	1	0	0	0	1	0,	"	15	93	" 23	47.98
1807	4	1	0	0	5	—6.5,	"	26	92	June 10	48.13
1808	0	0	0	0	0	+2,	"	19	98	July 17	49.48
1809	0	0	0	0	0	+1,	Feb.	9	94	" 10	47.92
1810	6	2	0	0	8	—5,	Jan.	20	97	May 29	49.00
1811	0	0	0	0	0	+1,	"	24	100	July 5	50.07
1812	4	0	0	0	4	—6,	"	18	84	" 4	45.28
1813	3	0	0	0	3	—7,	"	30	93, J.28, J. 9, S 13		47.70
1814	3	1	0	0	4	—4,	Feb.	4	93	July 15	48.27
1815	4	0	0	0	4	—9,	Jan.	31	99	" 25	47.60
1816	0	1	0	0	1	0,	Feb.	15	101	June 23	47.11
1817	3	4	0	0	7	—11,	"	14	97	July 18	47.27
1818	2	7	0	0	9	—11,	Jan.	30	100	June 30	48.00
1819	1	0	0	0	1	—2,	"	29	100	Aug. 1	50.75
1820	0	2	0	0	2	—8,	Feb.	2	100	June 30	48.70
1821	5	0	0	0	5	—13,	Jan.	25	100	Aug. 1	48.15
1822	7	0	0	0	7	—9,	"	14	97	July 1	49.81
1823	1	1	0	0	2	—6,	March	4	96	Aug. 8	47.58
1824	0	1	0	0	1	—6,	Feb.	5	94	" 19	49.25
1825	0	0	1	0	1	—3,	Dec.	13	101	July 21	50.99
1826	1	0	1	0	2	—9,	Jan.	31	98	May 15	50.28
1827	3	1	0	0	4	—7,	"	21	96	Aug. 6	48.46
1828	0	0	0	0	0	+3,	"	22	93	June 25	51.35
Total	68	34	14	1	117					Mean	48.86

Observations.—According to the above Table, it will be seen that of the 43 years, there were eight in which the thermometer did not fall so low as zero at all—that the greatest number of days in which the thermometer fell so low in any year, is 9, namely, in 1818, there being 2 instances in January, and 7 in February. In the whole 43 years, the thermometer fell below zero 117 times, viz: 68 in Jan. 34 in Feb. 14 in Dec. and one in March. Of the coldest days in the several years, 25 were in Jan. 10 in Feb. 6 in Dec. and 2 in March. Of the hottest days in the several years, 23 were in July, 9 in August, 17 in June, and 2 in May.

The four times at which these observations were made, were at 8 o'clock in the morning, at noon, at sunrise, and at 10 in the night.

THUNDER CLOUDS.

In New England, nearly every thunder cloud rises from the west, or north-west. In the valley of the Connecticut, it is exceedingly rare that a thunder cloud rises from any other quarter. At the city of Hartford, a thunder storm from the south, or east, is so uncommon, as scarcely to occur more than once in eight or ten years.

In Germany, from a series of observations on this subject, it appears that the general direction of electrical clouds is from the west towards the east, and but very seldom from the north, or south.

Philosophers are not yet acquainted with any general principles by which these circumstances can be explained. The form of the land, and especially the direction of chains of mountains, undoubtedly give direction to thunder clouds, by their attractive influence; so that from this cause, variations from their general course, may often be accounted for. But on what natural causes their general direction towards the south, or east, rather than towards the west, or north, depends, is unknown.

Appearances of Thunder Clouds. A thunder storm may generally be prognosticated by the appearance of

the horizon. A low dense cloud is seen in the north-west, which spreads itself out in both directions, forming an arch, the ends of which are below the line of vision. The color of the main cloud is bluish black, but there often gathers above this, clumps of a lighter color, which have a quick and irregular motion, in various directions, until they finally appear to coalesce with, and become a part of, the principal cloud.

The whole now begins to rise rapidly above the horizon, and to throw out at various points, vivid flashes of lightning, which, after a while, are followed by the well known sound of distant thunder. As the cloud approaches, the sky becomes darkened, the lightning increases in splendor, the thunder becomes louder, and the scene more appalling, until the eyes are blinded by the flash of the lightning, and the ears instantly stunned by a single crash of the thunder, when the most courageous and hardened of men, and even the beasts of the field, cannot but betray symptoms of alarm, or dismay.

How Lightning is Produced.—We have already shown that electricity and lightning are identical, both producing precisely the same effects, and exhibiting the same phenomena, under the same circumstances. When electricity is passed from one conductor to another, through the air, which is a non-conductor, there is always a flash of light produced. This is a miniature flash of lightning, and the report is diminutive in proportion, being a mere *snap*, which is heard to the distance of only a few yards. The same principle, when increased in quantity, produces the forked lightning, and the rolling thunder of the heavens.

Lightning appears to be produced under three several circumstances, namely, when the electricity passes from a positive, to a negative cloud; when it passes from a positive cloud, to the negative earth, and when it passes from the positive earth, to the negative cloud.

How is lightning produced? What are the several circumstances under which lightning is produced? Does the electricity always pass from the cloud to the earth, or not?

In the first instance, the lightning produces no effects on the earth, the action being merely to restore the electrical equilibrium between the two clouds. When the earth is negative, and the cloud positive, or the contrary, then it is that the destructive effects of the lightning are produced.

Many writers suppose that the earth is always in the negative state when compared with that of the cloud, and that the lightning invariably passes from the cloud to the earth. But there appears to be sufficient evidence, that the electricity passes in both directions, though much the most frequently from the cloud to the earth.

Thunder.—When a large quantity of electricity passes from a positive to a negative body, through the air, a vacuum is formed by the heat, and the concussion of the elastic atmosphere in again filling the vacuum, produces the sound which we call *Thunder.*

Thunder varies in intensity, and character, according to the height and extent of the cloud, and the physical peculiarities of the country in which it is heard. When the electrical discharge is very near, an instantaneous peal, or crash, is produced; but when far distant, a deep rolling, or rumbling, is heard. When the cloud is over a flat country, and there are no terrestrial objects to cause reverberations, there is a regular series of explosions, increasing or diminishing in intensity, as the distance becomes less or greater. When over a mountainous country, the same explosions are repeated by reverberations, and thus a continued rolling, interspersed with loud peals, are the consequence.

Distance of a Thunder Cloud.—To determine the distance of a thunder cloud, it is only necessary to count the seconds which intervene between the time of seeing the flash of lightning, and hearing the thunder, and then allow 1142 feet of distance, to each second of time. As we see the flash instantly, but as sound passes at the

How may the distance of a thunder cloud be known? What are the safest places during a thunder storm?

rate of 1142 feet per second, the number multiplied by the number of seconds, will give the distance. Thus, if 5 seconds elapse between the lightning and the thunder, the distance of the cloud will be $1142 \times 5 = 5710$ feet, or a little more than a mile.

Personal safety during a Thunder Storm.—In a house which has no conductor, the safest place is, undoubtedly, on a feather bed, in the middle of the floor. But when this is not resorted to, the middle of the floor, on a dry chair, with the feet in another chair, is the next place of safety.

In the open air, persons should never take shelter under a tree to avoid the rain, but should take a place at least 30 or 40 feet distant from any high object, which might conduct down the lightning. Many a life has been lost, by not observing this precaution.

Effects of Atmospheric Electricity.—Those who reside in temperate climates, can have no conception of the tremendous, and appalling phenomena, and the destructive effects which lightning sometimes produces in the tropical regions.

One of the most extraordinary instances on record, of the consequences of accumulated electricity in a cloud, happened in the Island of Java, in August, 1772. At midnight, a cloud was observed covering a mountain in the district called Cheribon, and several reports, like cannon, were heard by the people below, after vivid flashes from the cloud.

The inhabitants of the higher parts of the mountain, alarmed at the unusual appearance of the cloud, left their houses, and hastened towards the plains, but on their way, they were overtaken by the storm, which also descended down the mountain, and was seen tossing, and rolling like the troubled sea, and emitting globes of fire so luminous, and so often, that the darkness of the night gave way, and the whole region of the mountain became as light as though it had been illuminated by the noon-day sun.

Give an account of the great electrical storm of Java?

The phenomenon was terrific beyond description, to the people of the plains, but still more so to those of the mountain, since not only terror, but death itself, thus suddenly, and unexpectedly came upon them, in the dead of night. Such were the awful effects of the lightning, and the wind, and rain, that every thing was destroyed, for the distance of 20 miles around; the houses were demolished—the plantations torn up by the roots, or buried in the earth, the whole stock of cattle and horses perished, and 2140 human beings lost their lives.

Rock torn in pieces by Lightning.—On the Island of Fetlar, one of the Shetland Isles, Dr. Hibbert states, that about the middle of the last century, a rock of mica slate, 105 feet long, 10 broad, and in some places, 4 feet thick, was in an instant, by a flash of lightning, torn from its bed, and broken into three large, and several smaller fragments. One of the large pieces was 26 feet long, 10 broad, and 4 thick; this was simply turned over. The second, which was 28 feet long, 17 broad, and 5 feet thick, was hurled across a point to the distance of 150 feet. Another broken mass, about 40 feet long, was thrown still farther, being cast to a considerable distance into the sea. There were, also, many smaller fragments. scattered up and down in various directions.

It is said, that in the forests, while the oak, chestnut, and most other trees, are frequently scathed by the lightning, the beach is very rarely, or never, touched.

METEORS.

The sudden apparition, and short duration, of luminous bodies in the sky, appear to have been observed from time immemorial. These have received the several names of *fire-balls, shooting stars*, and *Meteors*.

Some of these are undoubtedly electrical phenomena, while others appear to be composed, partly of combustible, and partly of incombustible, solid matter.

These apparitions are not uncommon in the atmosphere, in different parts of the world, and have been

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What were the facts with respect to splitting a rock by lightning?

described by various writers. But as no general description would convey an idea of their appearance, we will describe a single one, of uncommon magnitude, as an illustration of the whole subject.

The description is given by an eye witness, who, at the same time, was highly qualified to describe what he saw, viz., Mr. Cavallo, a name well known in the annals of science.

This gentleman, with others, was standing on the terrace of Windsor Castle, about the hour of 9 in the evening, on the 18th of August, 1783, when some flashes of lambent light, much like the *Aurora Borealis*, were observed in the northern part of the heavens, which were soon perceived to proceed from a roundish, luminous body. Its apparent diameter equalled half that of the moon, and at the instant of discovery it appeared to be stationary. But it soon began to move, and to increase its light. Its path was about 25 degrees above the horizon, and its direction south-east. For a moment, its light was such as to show every object quite distinct; "the whole face of the country," says Mr. Cavallo, "in that beautiful prospect before the terrace, being instantly illuminated." At this moment, the body of the Meteor appeared of an oblong form; but it presently acquired a train, or elongation, and soon after, it parted into several small divisions, each of which had a train also. They all moved on in the same direction, at a small distance from each other, and a little behind the principal body, which was reduced by this division. In this form, the whole moved towards the south-east, when the light diminished abruptly, and then entirely disappeared. The whole duration of the Meteor, was about half a minute.

About ten minutes after its disappearance, a rumbling noise was heard, like that of thunder at a great distance, and which was attributed to the explosion of the Meteor.

Taking the noise heard, to be the explosion, Mr. Cavallo made the following calculations, with mathematical accuracy, in respect to its distance, size, and length of its path; estimating sound to pass at the rate of 1150 feet per second.

Distance of the Meteor from Windsor Castle, - - -	130 miles.
Length of the path it described in the heavens, - - -	550 "
Its diameter when fairly in sight, -	1050 yards.
Its height above the surface of the earth,	55½ miles.

Accounts of this Meteor, were afterwards received from various parts of Britain, and also from France; from which, it appears, that it passed over Scotland, as well as England, and that it was seen at Paris, Burgundy, and even at Rome, on the continent.

As Mr. Cavallo's calculations were made only to the time of the explosion, he supposes the whole length of the Meteor's path exceeded 1000 miles, and which it must have passed through in about one minute.

Meteors of 1833.—On the night of the 13th of November, 1833, the atmosphere was literally filled with falling Meteors, to a great extent on the globe, the descriptions of which, in most of the Newspapers, and Scientific Journals of the day, are too well remembered to require repetition here.

Professor Olmsted, of New Haven, collected, digested, and published in the 26th number of Silliman's Journal, a very full account of these phenomena, as they appeared to observers in different parts of the country, and from the information thus obtained, together with his own observations, he founded an explanation, or "Theory of Shooting Stars." But our limits only admit us to give some of its leading features.

1. "*The Meteors of November* 13*th*, 1833, *had their origin beyond the limits of the atmosphere.*"—This inference was founded on the fact, that the source of the Meteors moved along with the stars, to the westward, and therefore did not partake of the earth's diurnal motion, which, as the atmosphere revolves with the earth, would not have been the case, had the source of the Meteors been within its limits.

2. *The matter of which the Meteors were composed, was combustible.*—This inference was founded on the fact, that these meteors gave out their own, and not a borrowed light; in other words, that they were seen to burn.

3. *The matter of which the Meteors were composed, was specifically light.*—This was inferred from the observation, that they were retarded in their descent by the atmosphere.

4. *The Meteors were, at least, in many cases, large bodies.*—This seems to be proved by their apparent magnitude, which, in some instances, were equal to that of the full moon.

5. *There will probably be an annual return of Meteoric showers, on or about the 14th of November.*—This was inferred from a collection of facts, with respect to the falling of such showers during previous years, and from which it was ascertained that such occurrences had happened on the morning of the 12th of November, 1799, and on the mornings of the 13th of November, in the years 1831, 1832, and 1833. Hence it was supposed that the *Meteoric cloud*, or the source of the meteors, was situated over that point of the earth's orbit, which, during the annual revolution, was passed, on or about the 13th of November. And there are grounds for believing that this theory will prove true, since on the morning of the 13th Nov. 1834, '35, and '36, meteoric showers have been observed to a greater or less extent, in various parts of the world.

AURORA BOREALIS.

The northern lights, in some parts of the world called *merry dancers*, and in others *streamers*, are extraordinary meteoric, or luminous phenomena, which appear during the night, in the northern regions. They most commonly appear in the winter months, and during the coldest weather, though sometimes in the earlier part of the frosty season.

The periods at which the northern lights appear are quite uncertain, some winters in temperate climates, passing without their being sufficiently luminous to attract notice, while during other seasons, they happen nearly every night for weeks, or months. They are most frequent in high north latitudes.

"This phenomenon," says Dr. Granville, "is of frequent occurrence at Petersburgh, in Russia. According to the meteorological tables of 20 years, northern lights appeared 21 times in each year. In the year 1774, they appeared 48 times. From 1782 to 1786, they decreased, having been seen only 110 times during that period, and only 39 times from 1787 to 1799. This diminution in the yearly number of northern lights, has continued more or less ever since; and looking for illustration at the tables for the most recent years, I find that they occurred only six times in 1818, and twelve times in 1819."

"At the close of the last autumn," he continues, "this curious phenomenon appeared, on one occasion magnificently bright. The sky was illuminated from the horizon to the zenith, extending east and west to a considerable distance. Masses of fire, in the form of columns, and as brilliant as the brightest phosphorus, danced in the air, and streaks of a deeper light, of various sizes, rose from the horizon, and flashed between them. The brightness of the former, seemed at times to grow faint and dim. At this conjuncture the broad streaks would suddenly shoot, with great velocity, up to the zenith, with an undulating motion, and pyramidal form. From these columns, flashes of light, like a succession of sparks from an electric jar, flew off, and disappeared; while the streaks changed their form, frequently and rapidly, and broke out in places where none were seen before, shooting along the heavens, and then disappearing in an instant."

"The sky, in various places, became tinged with a deep purple, the stars shone very brilliantly, the separate lights gradually merged into one another, when the auroral resplendence of the horizon increased, and became magnificent. This phenomenon lasted nearly four hours; and at one time, a large triangle of the strong-

est light occupied the horizon, illuminating, in the most splendid manner, nearly the entire vault of the heavens. Six or seven falling stars, were observed at the same time, leaving in their train, a very brilliant light."

At Melville Island, in latitude 75° 50′ north, where Captain Parry wintered, the aurora, always appeared in the south, and he therefore called it *Aurora Australis.*

The northern lights were anciently regarded, even by philosophers, with superstitious dread, and were believed to be the harbingers of war, pestilence, or famine, and especially the first. Hence the imagination saw in these phenomena, pictures, representing garments dyed in blood, and all the other attendants of horrid war. Thus Cornelius Gemma, in 1575, during an aurora, saw with his own eyes, at Brabant, fortified cities, and armies fighting in the air, with all the instruments, parade, and horrors of war.

Cause, and Height of Auroras.—Few meteorological phenomena have excited more attention, not only among the common people, but also among philosophers, than this. In the highest northern regions inhabited by man, as well as in Sweden and Lapland, the northern lights, during the long nights of winter, are, in different degrees, almost constant, and are of great consequence to the inhabitants, serving to give the traveller, and the husbandman, sufficient light in the absence of the moon.

The Aurora is evidently an electrical phenomenon, and may be imitated by ordinary electricity. When this agent is passed through a vacuum, beautiful streams of light are produced, which vary in color and intensity, according to the quantity of air still remaining in the vessel. Dr. Farraday considers it probable, that the aurora is a luminous representation of electricity, flowing from the equator towards the poles, for the restoration of the electric equilibrium.

During the auroras, the *electricity* of the atmosphere, as indicated by the electrometer, is much more decided than at other times, and there is always a greater quantity of that agent, excited by the same means, in winter

than in summer. But why it happens that this phenomenon is sometimes so brilliant, as to enlighten half the northern hemisphere at one time, and then is scarcely seen again, in the same latitudes, for years, we cannot explain.

Aurora Borealis of January 25th, 1837.—While writing the above, there happened, on the evening of the 25th of January, one of the most brilliant auroras we have ever seen, or which has happened in this country since 1774.

The northern light was first observed about 6 o'clock, and was mistaken by many persons, for a tremendous conflagration at the distance, as was judged, of ten or twelve miles. The whole northern horizon, to the height of about 25 degrees, and extending to the north-west and north-east, had the appearance of the rising sun, only that it was more extensive in all directions.

In the course of an hour, the enlightened portion of the celestial sphere, became more extensive, and finally reached the zenith; after which, streams of colored light began to arise from the north, which soon after reached the zenith, when the whole sphere, in all directions, except that of about 40 degrees above the horizon in the south, became illuminated with a yellowish light, which being reflected from the snow, gave a striking, and peculiar, and to some, a fearful effect, to the scene.

At half past 10, luminous stripes shot up from the north-west, of a silvery hue, flashing, and dancing, in a manner which has obtained for this appearance, the denomination of *merry dancers*, in the northern regions. Meantime the columns of light, frequently, and sometimes momentarily changed from orange, to flame color, and from this to dark purple, forming patches, and stripes, both east and west of the zenith, covering the stars in most of the upper vault of the heavens, and giving them different and peculiar tinges of color, according to that through which they were seen.

The sky, during the whole time, was cloudless, and the atmosphere still; so that at every instant

of the entire movement of the phenomenon was distinctly apparent; and on the whole, presented the most brilliant and striking example, of that mysterious spectacle, the Aurora Borealis, which was probably ever seen in this country.

FIRE OF ST. ELMO.

This light was formerly supposed by mariners, to be a visible representation of a spirit they called St. Elmo, and who was the tutelar saint of those who traverse the mighty deep; and hence its name.

St. Elmo's Fire is a luminous meteor that frequently appears to settle on the mast-head of vessels, in warm weather, and especially in hot climates, and is considered an electrical phenomenon, though is is never known to produce any of the disastrous effects of lightning. When it is confined to the topmast, it is considered a prognostic of bad weather, though not in such a degree as to do injury. But when it descends down the mast, it is believed a sure proof that a storm is coming, which will be, more or less disastrous, in proportion to the distance it descends.

Falconer, in his Shipwreck, alludes to this, when he says—

> "High on the mast, with pale, and livid rays,
> Amid the gloom, portentous meteors blaze."

This appearance is explained by the known aptitude of pointed conductors to transfer the electricity of the atmosphere, in silence, or without a shock, and hence the reason why sharp points are made to terminate lightning rods.

It is possible that the light of St. Elmo, may be connected with a change of the weather, since the electrical state of the atmosphere is undoubtedly concerned in the production of clouds and storms, as well as in that of lightning and thunder. It would not, therefore, be unphilosophical to consider, with the sailors, that these appearances prognosticate such changes.

Humboldt, during one of his voyages, observed this phenomenon, and thus describes it; "On observing the appearance of the masts, the main-top-gallant-mast-head, from the truck, to three feet down, was perfectly enveloped in a cold blaze of pale phosphorus-looking light, completely embracing the circumference of the mast, and attended with a flitting, or creeping motion, as exemplified experimentally, by the application of common phosphorus upon a board. The fore, and mizzen-top-gallant-mast heads, exhibited a similar appearance. This curious illumination continued with undiminished intensity, for eight, or ten minutes, when becoming gradually fainter, and less extensive, it finally disappeared, after a duration of not less than half an hour."

From the same cause, arose the phenomenon observed by M. Allamond, who, having closed his umbrella during a thunder storm, lest the electricity should be attracted by its metallic point, saw that the brim of his hat was surrounded by a broad band of light, which became more intense, as he passed his hand over it. This appearance vanished as soon as he came near to some tall trees, which probably conducted the electricity to the ground, from the highly excited atmosphere.

PHENOMENA OF ATMOSPHERIC REFLECTION AND REFRACTION.

It would be improper to end our account of the Phenomena of the Atmosphere, without adverting to several curious, and formerly considered, mysterious, effects of atmospheric refraction, and also to the reflection of images from atmospheric vapor.

This subject is of considerable importance, inasmuch as it explains several illusive appearances, which those ignorant of their causes, have believed, and are still liable to believe, are supernatural.

"It is impossible," says Dr. Brewster, "to study these [Atmospherical] phenomena, without being impressed with the conviction, that nature is full of the marvel-

lous, and that the progress of science, and the diffusion of knowledge, are alone capable of dispelling the fears which her wonders must necessarily excite, even in enlightened minds."

When in the midst of solitude, and in situations where the mind is undisturbed by sublunary cares, we see our image delineated in the air, and mimicking in gigantic perspective, the tiny movements of humanity, as in the *Spectre of the Brocken;* when we see troops, in military array, performing their evolutions on the face of an inaccessible precipice, as in the case we shall describe, or when ships are seen in the air, though none are within the distance of many leagues, and far beyond the reach of the eye—when such varied and striking phantasms are often seen, and therefore appear in the character of the real phenomena of nature, our impressions of supernatural agency, can only be removed by a distinct, and satisfactory knowledge of the causes.

SPECTRE OF THE BROCKEN.

The *Brocken*, is the name of the loftiest of the Hartz Mountains, a range, celebrated for its mineral treasures, and its picturesque scenery, situated in the kingdom of Hanover. The elevation of the Brocken is 3300 feet above the level of the sea, and commands a view of a fine level country of great extent, and populated by more than five millions of inhabitants.

From the earliest periods of history, the Brocken has been famed as the seat of the marvellous, and it is supposed that its summit was consecrated to rites of idolatry, and that the image of Cortho, a heathen deity, was worshipped there by the Saxons, long after Christianity had begun to spread its benign influence over the plains below; and it is probable that the spectres seen there, when their cause was unknown, might have had some connection with the superstitious rites of the devotees.

The following account of the Spectre of the Brocken is given by M. Haue, who saw it on the 23d of May, 1797. After having been on the summit of the moun-

tain no less than thirty times, he had at last, the good fortune to witness the object of his curiosity. The sun rose about 4 o'clock, through a serene atmosphere. In the south-west, a brisk wind carried before it transparent vapors, which had not yet condensed into clouds.

About a quarter past 4, he went towards the inn, in order to ascertain whether the atmosphere would afford him a free prospect towards the south-west, when he observed at a great distance towards the mountain called Achtermanshole, a human figure of enormous size.

M. Haue's hat, having, at this moment, been in danger of blowing away by a sudden gust of wind, he raised his hand to his head in order to save it, and the collosal figure did the same. He now saw, that his long wished-for object was attained, and that the Spectre of the Brocken was indeed before him, and continued to make further experiments, by throwing himself into various positions, which his giant image simultaneously imitated. He then called the landlord of the inn, and having both taken the same position which M. Haue occupied before, they saw nothing for some minutes. But soon after, two colossal figures made their appearance, side by side, in the same place, where one was seen before; and after mimicking the various gestures of the spectators, they suddenly disappeared.

Retaining their positions, and keeping their eyes fixed on the same place as before, the two gigantic spectres again stood before them, *and were joined by a third.*

Every motion that they now made was imitated by three figures, instead of two, but the effect was varied in its intensity, being sometimes weak, and faint, and at others, strong and well defined.

This scene is represented by fig. 38, which shows the rising sun; the two men on the top of the mountain; and the three magnified images pictured on the mass of clouds in the distance.

Explanation.—The Spectres of the Brocken, which, in the times of ignorance, rendered that mountain so mysteriously celebrated, are merely the shadows of the

observer, projected on dense vapor, or thin fleecy clouds, which have the power of reflecting much light.

Fig. 38.

The reason why they are often seen at this particular spot, arises from the peculiar situation of the two adjacent mountains, with respect to each other, and to the rising sun. The fact that clouds or mist, are often seen to envelope the tops of moderately high mountains, in the early morning, is well known. The figures are seen at sunrise, because then the sun throws his rays in a horizontal direction, otherwise the shadow would be thrown upon the ground.

If there are two, or more persons observing the phenomena, as when M. Haue and the landlord, saw it together, each observer will see his own image most distinctly, and the head will be generally more distinct than the other parts of the figure, because the rays of the sun will be more copiously reflected at a perpendicular incidence from the cloud. M. Haue mentions the extraordinary circumstance of a third figure, joining those of himself and the landlord; but he does not inform us which of the two figures was doubled, which might at once have been known by the gestures. Possibly a third person might have stood behind them for a few moments, and then concealed himself, in order to make the spectacle more striking and inexplicable. If not, still the phenomenon is readily accounted for, by the duplication of one of the figures, in consequence of the unequal refraction of the cloud.

Aerial Reflection of a Troop of Horsemen.—On a summer's evening, in the year 1743, when Stricket, servant to John Wren of Wilton Hall, was sitting at the door, along with his master, they saw the figure of a man, with a dog, pursuing some horses along Souterfell side, a place so very steep, that a horse could not travel upon it. The figures appeared to run at an amazing rate, until they passed out of sight at the further end of the precipice, and what increased this marvel still more, was, that those figures were on the opposite side of the hill.

On the following morning, Wren, and his servant, ascended the steep side of the mountain, in the full expectation of finding the dead man, and of picking up some of the shoes of the horses, which they thought must have been cast, while galloping at such a furious rate. Their expectations, of course, were disappointed. No traces of the horses, or man, could be found; and they could not even discover on the turf a single mark of the horses' hoofs. This strange apparition, seen by two witnesses in perfect health, and sitting at their own door, could not fail to make a deep impression upon their minds; but when they told what they had seen to others, they were only laughed at for their credulity.

In the following year, on the 23d of June, Stricket, being then servant to Mr. Lancaster, saw from a different position, and on the opposite side of the same mountain, a troop of horsemen, riding in close ranks, and at a brisk pace. Remembering the ridicule, which had been cast upon him the year before, for his superstition, and credulity, he observed the figures in silence, when being convinced that what he saw was no deception, he ran to the house to inform his master, and to show him a sight so strange and unaccountable. Mr. Lancaster and his family immediately went to the spot, and the phenomenon was seen by them all. The equestrian figures seemed to come from the lowest parts of Souterfell, and became visible at a place called Knoll.

They advanced in regular troops along the side of the hill, and passed over the mountain, and out of sight at a certain point. They moved at a swift walk, and in good

order, and continued to be seen for upwards of two hours. Many divisions were seen in succession, and frequently the last but one in a troop would quit his position, gallop to the front, and then take the same place with the rest. The number of persons who witnessed these phenomena, were twenty-six; and the facts were sworn to, by Lancaster, and Stricket, in 1785.

Explanation.—In order to explain this mystery, we must advert to the well known law in optics, that the rays of light are refracted in their passage through any transparent medium of unequal density in its different parts. Thus, if ether be placed on water, the two fluids will bend, or refract the rays of light unequally, as they pass through the different strata. The same effect will be produced, if clear, transparent syrup be placed in a glass vessel, and water poured on it. If the vessel be square, so that an object can be seen through both substances, the object will appear distorted, owing to their different refractive powers.

The effect of this principle, in the atmosphere, may be witnessed at any time, by observiag the moon, at the moment when it rises above the horizon, at which time its form appears to be oval, the horizontal, being greater than the vertical diameter. Now the refractive power of the atmosphere is in proportion to its density, and its density being greatest nearest the earth, the lower limb of the moon is refracted in a greater degree than its other parts, and hence its oval form. The sun, at the moment of its rising or setting, has the same form. As currents of the atmosphere, of different degrees of temperature, and consequently of different densities, and refractive powers, are constantly moving along the surface of the earth, or rising to the higher regions, it is plain, from what we have already stated, that whenever a warm, and a cold stratum happen to meet, the former being upon the latter, the refractive power of the whole will thereby be greatly increased. It is under such circumstances, that, in high northern latitudes, where the density, and consequently refractive power, of the atmosphere is greatly increased by the cold, the sun be-

comes visible for hours before it actually rises above the horizon, the rays of light being bent round the convexity of the earth by refraction.

The appearance of the aerial troopers at Souterfell, was produced by this cause, the unequal refraction of the atmosphere having, in effect, brought them from one side of the hill to the other. It is most probable that these troops were exercising in secret, and preparing for action during the rebellion which broke out in 1745.

Inverted images of Ships.—Sometimes the refraction of various strata of the atmosphere, is such as to cause the rays coming from the object to cross each other, when the image will appear inverted. In other instances, the images are variously distorted, or only portions of them seen in succession.

This happened to Capt. Scoresby, when navigating the sea west of Greenland, in 1820. About 6 in the evening, a light breeze at north-west having sprung up, a thin stratum, or fog bank, at first considerably illuminated by the sun, appeared, and gradually rose to the altitude of about a quarter of a degree. At this time, most of the ships navigating at the distance of 10 or 12 miles, began to change their forms and magnitudes, and when examined by a telescope from the mast head, exhibited the most extraordinary appearances. One ship had a perfect image of another united to its mast head, in a reverse position. Two others, presented two distinct inverted images in the air, one of them a perfect figure of the original, and the other wanting the hull. Two others were strangely distorted, their masts appearing of at least twice their proper height, the top-gallant-mast forming one half the total elevation. Other vessels exhibited an appearance totally different from the preceding, being compressed into a smaller bulk, instead of being elongated. Their masts seemed to be scarcely one half of their real altitude, in consequence of which one would have supposed that they were greatly keeled to one side, or in the position called *careening*.

Along with the images of the ships, a reflection from the ice, sometimes in two strata, also appeared in the

air, and these reflections suggested the idea of cliffs composed of vertical columns of alabaster.

Capt. Scoresby observed these phenomena at intervals, during several days, sometimes extending continuously through half the horizon, and at others only in detached spots in various quarters. The inverted images of distant vessels were often seen in the air, *while the vessels themselves, were far beyond the reach of the vision.*

In a subsequent voyage, to the same region, Captain Scoresby having observed an inverted ship in the air, he directed his telescope towards it, and found that it was his father's ship, the Fame, though at that time it was far below the horizon. "It was," says Capt. Scoresby, "so well defined, that I could distinguish, by a telescope, every sail,—the general rig of the ship, and its particular character; insomuch that I confidently pronounced it to be my father's ship, the *Fame*, which it afterwards proved to be; though on comparing notes with my father, I found that our relative positions, at the time, gave a distance from one another, of nearly 30 miles, being about 17 miles beyond the horizon, and some leagues beyond the limit of direct vision. I was so struck with the peculiarity of the circumstance, that I mentioned it to the officer of the watch, stating my full conviction that the Fame was then cruising in the neighboring inlet."

The representation of ships in the air by the unequal refraction of the atmosphere, has undoubtedly given rise to the stories of the phantom ships, formerly seen on our coasts by our forefathers. The superstitious notion of the Flying Dutchman, so generally believed by sailors, to be a reality, undoubtedly had the same origin.

METEOROLITES, OR METEORIC STONES.

The fall of stoney bodies from the atmosphere, now a fact as well established as any other, either in history or science, is a phenomenon which affords an instructive example of the triumph of human testimony, over the scepticism of philosophy. The chronicles of almost

every age and nation, had recorded the fall of heavy bodies from the air, but the evidence had been generally rejected, both by historians and men of science, because the fact was denied as a philosophical impossibility.

It is a very remarkable circumstance in the history of this subject, that all the stones, in whatever period, or in whatever country they fell, have been found to be composed of the same substances, and nearly in the same proportions; and that nothing of a similar composition has ever been found, as a natural product, of the earth.

They are covered with a thin crust of a deep black color, and their surfaces are roughened with small asperities. Internally they are grayish, and of a granulated texture, more or less fine; but in which may always be distinguished by a lens, four different substances. The first, and most abundant, is from the size of a pin's head, to that of a pea, of a grayish brown color, and so hard as to give fire with steel. The second is composed of sulphur and iron, of a reddish yellow color, and not attractable by the magnet. The third consists of small particles of iron, in a perfectly metallic state, which gives to the whole mass the quality of being attracted by the magnet. The fourth is of an earthy consistence, which connects the others together; is of a dark color, and so soft as to yield to the nail.

The composition of these stones have been very carefully ascertained by chemical analysis, and found to consist of Silex, Magnesia, Oxide of iron, Oxide of Nickel, and Sulphur, in various, but similar proportions.

In every instance where these stones have been proved to have fallen from the air, and of which any particulars have been given, the appearance of a luminous meteor, exploding with a loud noise, has immediately preceded their descent, and hence has been considered as connected, in some way, with their production, or fall.

Various theories have, from time to time, been pro-

What are meteorolites? What is said of the peculiar composition of these stones? Is any thing of the same composition found in the earth? What are the ingredients which these stones contain?

posed by philosophers (since they have ascertained the fact of their fall), to account for a phenemenon, so improbable and mysterious. Some have supposed that they are thrown from volcanoes, a most improbable supposition, since they are known to have fallen thousands of miles from any volcanic country, and besides, no volcanic products have ever been found of the same composition. Others have suggested that they might come from the moon; but this is, perhaps, not less improbable than the other theory, since the projectile force, in this case, must be supposed sufficient to throw these bodies beyond the moon's attractive influence, or to such a distance, into space, that the earth's attraction would be greater than that of the moon, which therefore must be many thousand miles. Of the existence of such a force at the moon, we know nothing, and therefore this hypothesis is mere matter of conjecture, without any circumstances in its favor.

President Clap, of Yale College, many years since, proposed to account for these phenomena by supposing that the bodies which form the meteors may be solids, revolving round the earth, as the satellites do about their primaries, and that now and then, from some cause unknown, they come so near the earth as to lose their centrifugal force by her attraction, when, of course, their fall becomes inevitable. This is the most probable of the theories we have mentioned; but still it wants that circumstantial evidence, which is generally considered necessary to substantiate a scientific theory.

It may therefore be stated, that not even a satisfactory conjecture, has yet been proposed to account for the origin of Meteorolites.

Phenomena attending the fall of Meteorolites. — As these bodies are liable to fall in all parts of the earth, we will give an example or two, of the phenomena which have attended their descent, as it is possible some of the readers of this volume might otherwise witness such phenomena, without knowing their causes, and without making further inquiries.

On the 13th of September, 1768, about half past 4,

P. M. there was seen, near the castle of Luce, in Bavaria, a tempestuous cloud, from which was heard an explosion like thunder, without any appearance of lightning. After this, there was heard a remarkable whizzing noise in the air, and some travellers saw an opaque body descending in a curved line, which fell to the ground. They ran instantly to the spot, and found a kind of stone which was burning hot, and which was afterwards found to weigh seven and a half pounds.

That part which was buried in the ground, was of an ash-gray color, but that which was exposed to the air, was covered by a thin black crust, which appeared to have been melted. The interior of the mass, when broken, and examined with a magnifying glass, appeared spotted with a great number of brilliant metallic points, of a yellow color.

It does not appear, however, that clouds always attend the fall of these bodies, though this is often the case.

In the afternoon of the 13th of December, 1795, a noise was heard in the air, by many persons, at Yorkshire, England, which resembled the reports of guns at sea. A hissing noise through the air, and two distinct concussions on the earth were also heard. At the same time, a laborer working in the field plainly saw a heavy body coming down from the air, and in falling, sparks of fire were emitted from it. It struck into the ground so near, as to throw the earth all about him.

Having given notice to others, the spot was examined, and a stone was found buried about 20 inches deep. It was taken out, and measured 30 inches long, and 28 broad, and weighed 56 pounds.

The number of well authenticated instances of similar falls from the air, which have been recorded, amount to many hundreds. These have most of them been collected, and arranged in a table, by Mr. Howard, and from which we extract a few instances, on account of their extraordinary sizes, or numbers.

In 1492, a stone fell in Alsace, which weighed 260 pounds.

It is now in the library of Colmar, but has been re-

duced, by the curiosity of the people to have specimens, to 150 pounds.

In 1510, about 1200 stones fell in a field near the river Abdua, one of which weighed 120, and another 60 pounds.

In June, 1668, two stones fell near Verona, in Italy, one of which weighed 300, and the other 200 pounds.

In 1790, July 24th, a great shower of stones fell in the vicinity of Bordeaux, in France. Some of them weighed 25, and others 30 pounds. One mass 15 inches in diameter, fell through a hut, and killed a herdsman, and a cow.

In 1803, April 26, a great shower of stones fell near Aigle, in France. They amounted to 3000 in number, the largest of which weighed 17 pounds.

In 1807, December 14th, a shower of stones fell at Weston, in Connecticut, some of which weighed 20, 25, and 35 pounds.

Fall of Meteoric Iron.—Besides stones, iron is also known occasionally to fall from the air, though the cases of this kind are much less numerous than those of stones.

The appearance of meteoric, does not differ materially, from that of common iron. The masses sometimes contain eight-sided crystals. The outside is generally covered with a coat of the brown oxide. The middle is soft, and malleable, and in the composition nickel is always found.

The masses of this metal which have fallen from the air, are sometimes of great size. In their descent, they are attended with meteoric fire, and explosions, like the meteorolites.

The following are among the instances in which considerable masses, of iron have fallen. Not all of them however, have been seen to fall; but the peculiar composition of masses of known meteoric origin, together with the situation in which other masses have been found (lying on the surface of the earth), and the identity of their composition, are considered a sufficient proof of their common origin.

Professor Pallas states, that in his travels, he saw, on

the top of a mountain in Siberia, a mass of native iron, weighing 1680 pounds, and which the people declared to him, fell from the clouds.

In 1751, two masses of iron fell from the sky in the district of Angram, the capital of Croatia. The largest, weighing 71 pounds, is now in the Imperial Cabinet of Vienna. The inhabitants reported, that the appearance of the mass before it fell, was like that of a globe of fire in the air.

A mass of meteoric iron, now in the Cabinet of Yale College, weighs upwards of 3000 pounds. Its surface is covered with a dark brown crust, and is deeply indented. This was found near Red River, in Louisiana.

In the province of Tucuman, in the midst of a large plain, in South America, Don Rubin de Celis describes a mass of native iron which weighs 30,000 pounds. It has an irregular, indented surface, and is cavernous internally.

A great number of similar masses are described by writers, but these are sufficient for our purpose.

PHENOMENA OF THE INTERIOR OF THE EARTH.

We have, in the beginning of this volume, given a general description of the earth's surface, with such an outline of its Geological features as the design of the work seemed to require. We have also described some of the changes which have been wrought on its surface, both by Aqueous, and Igneous causes, and have described those phenomena in which the Atmosphere is concerned.

We are now to describe phenomena belonging to the interior of the earth, not embraced in any of the foregoing articles.

INTERNAL HEAT OF THE EARTH.

It was long since proposed to account for the action of volcanoes, by supposing that the interior of the earth is still in a state of igneous fusion, and that earthquakes and eruptions depend on the distribution of this great

mass of melted lead, by some natural cause. Possibly, it has been suggested, this disturbance may arise from the occasional admission of water upon the ignited mass, and the consequent production of steam, or, if the heated matter be composed in part, of metallic substances, the production of hydrogen from the decomposition of the water; in which case, both steam and gas would act to produce the effect.

It is, however, but recently, that any decisive experiments have been made, in order to ascertain whether this theory of central heat had any foundation in truth, and whether the earth was really any warmer at a great depth below, than near the surface, and this question after about 300 experiments, in the deepest mines of various countries, has been very clearly decided in the affirmative.

Thermometrical observations for this purpose, have not only been made on the rocks and earth of mines, but also on the water issuing from them. These experiments have been conducted with every attention to accuracy, and the utmost care has been taken to avoid deception of every kind.

After a series of observations by Mr. Fox, in one of the Cornwall mines, at the depth of 1380 feet, which observations were continued for eighteen months, it was found that the mean temperature of the mine was 68°, while that of the surface was 50°. This gives one degree of increased heat for every 75 feet of descent, from the surface to the bottom of the mine.

From observations made in six of the deepest mines of Durham and Cornwall, in England, it was found that the mean rate of increase was one degree for every 44 feet of descent from the surface.

From a series of observations made in several of the lead and silver mines of Saxony, it was decided that the mean increase of temperature was one degree for every 65 feet of descent from the surface. In these cases, the experiments were made by introducing the ball of

What were the mean temperatures of the Cornwall mine, and the surface of the earth, according to Mr. Fox's observations? What was the result of M. Cordier's observations?

the thermometer into cavities cut in the solid rock for that purpose.

M. Cordier, a French writer, having collected and digested all the experiments which had been made on this curious subject, and taken the average of the different thermometrical observations, comes to the conclusion, that the mean increase of temperature is equal to one degree for every 45 feet of descent below the surface of the earth.

Objections to the doctrine of central Heat.—The fact that the earth increases in temperature, in some proportion to the depth below the surface, has been established beyond all controversy, but whether this arises from a permanent and universal cause, existing in the earth itself, or from extraneous circumstances, is a question which has been sharply contested.

Some writers, denying the real increase of the earth's temperature downwards, have attributed the indications of the thermometer to several sources of deception, as the condensation of the air; the influence of the animal warmth of the miners, and the heat of their lights in the mines. The air, we know, gives out heat by pressure, as is proved by its condensation in a syringe, by which substances may be set on fire. On the contrary, cold is produced, or heat absorbed, where the air is rarified, as in the higher regions of the atmosphere.

With respect to this objection, Mr. Fox has shown that in the mines of Cornwall, where from the different shafts, there are ascending and descending currents of air, the former have a higher temperature than the latter. The difference between them was, that the ascending current raised the mercury from 9° to 17° higher than the descending, a proof that instead of imparting heat to the mines, these currents actually carry away large quantities of caloric from them.

With respect to personal warmth, and the influence of lights in increasing temperature, the objection would hold equally true, at a small, as well as a great depth in

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According to the rate of increasing heat, at what depth below the surface would water boil? What would be the temperature at the centre, at the same rate?

the earth, so that, if the increased temperature be attributed to this cause, that of a shallow and a deep mine ought to be the same, which we have seen is not the case.

Finally, without further adducing the experiments, or reciting the arguments which have been brought to bear on this subject, it will be sufficient for the design of this work, to state, that from all the experiments which have been made, there appears to be no doubt but the temperature of the earth increases progressively with the depth (so far as experiments have been made), and that, if the same ratio of increase continues below where the experiments have been made, the ordinary point of boiling water would be about two miles from the surface.

Continuing downwards from the boiling point of water, which is 212°, and fixing the ratio of increased temperature at one degree for every 45 feet, we shall have a constant increment of heat passing through the melting points of all the metals, earths and stones, until arriving at the centre of the earth, when, according to M. Cordier, we should have a temperature equal to 450,000° of Fahrenheit, which is about twenty times the heat of melted iron.

This being the case, we stand on a comparatively thin crust of cooled earth, with this vast Ocean of melted lava beneath us.

Tides of the Melted Lava.—Now, since we know that the effect of the Moon's attraction on the waters of the Ocean, is to produce tides, there can be no reason why the same consequences should not follow on the Ocean of fluid lava, though it is situated under the crust of the earth: and accordingly, M. Cordier admits that there must be a flux and reflux in the matter of this internal Ocean, which formerly, when the fluidity of the globe was perfect, could not have been less than from 13 to 16 feet; but he says, they have now become feeble, owing to the great depth to which the earth has

cooled, so that this body of internal liquid is much less than formerly, and consequently the tides have diminished in proportion.

Admitting that these tides have become incapable of elevating the thick crust of the earth, of which, at present, there is no evidence of their doing, whatever might have been their former effects, still, it may be asked, if there is an ocean beneath, as of liquid fire, ought not jets of lava at the mouths of open volcanoes, to be projected every six hours, or when the attraction of the moon must inevitably disturb the equilibrium of this ocean? And, on the contrary, ought not the eruption of Stromboli, which has continued for 2000 years, to cease every six hours, on the ebbing of the tide, if such an ocean exists?

We cannot here go into the arguments which philosophers have adduced, to prove, and disprove the existence of a central ocean of melted lava. There is no doubt that the heat increases downwards, as far as observations have, or can at present be made, and from what cause, remains to be explained. But the theory which maintains the actual existence of a degree of heat at the centre of the earth, twenty times greater than that of melted iron, appears to be incompatible with the known laws of the equal distribution of temperature through fluid bodies. For if such a degree of heat did exist there, its tendency to equalize the temperature of the whole mass of the earth, would also melt the crust on which we stand.

THEORY OF VOLCANOES.

We may theorize on the causes of volcanoes and earthquakes, as arising from the occasional production of internal heat, without supposing the entire contents of the globe beneath its crust, to be a fused mass.

When Sir H. Davy first discovered the metallic bases of the earths, and alkalies, he threw out the idea that these metals might abound in the unoxydized state in the

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What are the objections to supposing the central parts of the earth to be melted lava?

subterranean regions, and to which water might occasionally penetrate.

Now had the globe been originally formed with the earths unoxydized, their combination with the oxygen of the atmosphere, would, he says, have formed a crust of earthy matter, as a superficial covering, the interior still remaining a deoxydized metallic mass. If water should, by penetrating through the crust, reach the metallic mass, a chemical action would be immediately produced: the oxygen of the water having a great affinity for the metals, would be absorbed by them, and the hydrogen thus disengaged. The chemical action of the water and metals would produce a degree of heat sufficient to melt the surrounding rocks, while the hydrogen gas, by its great volume, elasticity, and inflammable property, would rend the crust of earth, and burst into flame, on exposure to the air.

In this manner, did Sir H. Davy propose to account for volcanic eruptions, and earthquakes. But a difficulty is immediately suggested by the fact that particular sections of country, have been, from time immemorial, subject to earthquakes and volcanoes, a circumstance apparently incompatible with this theory, since all the earth in such regions, must long ago, have been oxydated, in order to have produced these continued effects. The question then arises, whether there is any known agent developed in the several processes of decomposition within the earth, which, in its turn, has the power of depriving the earthy compounds of their oxygen, so that a series, or circle of chemical effects might be produced, which would account for the continuance of volcanic action in the same place, for long periods of time.

Now when the metallic bases of the earth and alkalies, are exposed to water, the oxygen of the fluid is absorbed, and the hydrogen, the other component of water, is evolved, or set free. On the contrary, when a metallic oxyde is exposed to hydrogen at a red heat, the oxygen of the compound is absorbed, and the metal is again reduced to its pure state, while the two elements of water by their union in their turn, produce that fluid.

Thus it appears, that we have a deoxydating agent in

one of the elastic chemical products, which arises from the action of water on the unoxydated metallic bases, and thus the continued action of volcanoes may be accounted for.

If now, we suppose that the crust of the earth is the oxydized portion of the earths and alkalies, and that at some unknown depth, the bases of these substances still exist in their pure metallic states, as they were originally formed, and then suppose that water is occasionally admitted to this metallic mass, we may, perhaps, account as satisfactorily for the phenomena of earthquakes and volcanoes, on this theory, as on any other which has been proposed.

The increased temperature of mines may also be accounted for, by supposing that the general moisture of the earth under ordinary circumstances, reaches the unoxydized substances in just sufficient quantities to keep up the temperature without producing an explosion. But when the quantity, by any means, is increased, small earthquakes are produced, and when large quantities are admitted, then those terrible convulsions happen, which destroy cities, and deluge the vicinities of volcanoes with rivers of burning lava.

Besides the metallic bases of the earths, there are other substances within the crust of the globe, which are known to evolve heat when exposed to moisture. Thus, let a considerable quantity of iron filings be mixed with a larger proportion of sulphur, and as much water added as to make the whole into a firm paste. Let this mixture then be buried in the earth, and the soil firmly pressed down upon it. In a few hours, it will grow warm, and swell so as to raise the ground; sulphureous vapors will make their way through the crevices, and sometimes flames will appear. In some instances, though rarely, there is an explosion, attended with vivid streams of fire, which continues for a considerable time.

Where sulphur and iron exist, as a natural compound, in that mineral called *Sulphurate of Iron*, the addition of considerable quantities of water, will produce heat, or, in some instances, spontaneous combustion. Thus,

when the refuse of coal mines, containing large portions of this mineral, are thrown into heaps, the rain causes in the mass, a smouldering heat, in consequence of the new chemical combinations which take place between the sulphur, iron, and water, and sometimes the heat is sufficient to cause the ignition of the mass, and the consequent inflammation of the hydrogen, which is extricated. It is the contact of water, and not of air, which causes the heat, and hence, it is possible, in many instances, that the internal temperature of the earth, may, in certain places, be owing to this cause.

It must, however, be confessed, that, after all the many theories that have been offered to account for earthquakes and volcanic eruptions, as well as for the cause of the internal heat of the earth, there still remains great obscurity on these subjects. Nor is it very probable, that in the present state of knowledge, any explanation of these phenomena will be proposed, which will account satisfactorily, for all the facts they exhibit.

HOT SPRINGS.

The occurrence of Warm, or Hot Springs, in almost every country, is sufficient to prove, that to whatever cause the internal heat of the earth may be attributed, the effect is very generally distributed.

In many instances, warm Springs gush forth from the earth at great distances from any volcanic tract, as in the case of that at New Lebanon, in the State of New York. The waters of this Spring, are 73°, (the temperature of ordinary Spring water being from 44 to 50°), and we believe have not varied in temperature since it has been known; and yet, no volcanic country exists within several thousand miles of this place. The cause which maintains the internal temperature of this spot, must, therefore, either be different from that which produces volcanoes, or is insufficient in degree. Did the temperature depend on the ancient heat of the

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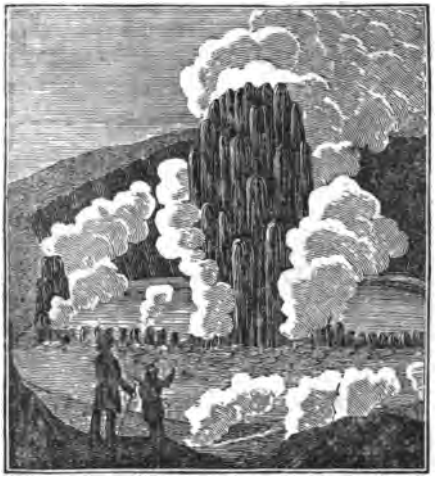
Is there any satisfactory explanation of the cause of volcanoes and eruptions? What seems to be proved by the occurrence of warm springs, in almost every country? What is said of the New Lebanon spring?

earth, and not on some chemical action, still going on, we might expect that as the earth cools, the temperature of the waters would diminish.

Hot Springs of Iceland.—It is, however, in volcanic countries, that Hot Springs, or those of high temperatures, are principally found, and no part of the earth is so celebrated in this respect, as Iceland, the surface of which, almost every where consists of volcanic products.

Dr. Henderson, during his residence in Iceland, visited a Jutting Pool, in the crater of the Krabla, or Obsidian mountain, of which he gives the adjoining representation, and the following description.

Fig. 39.



Having passed a desolate farm, and keeping at a distance from the sulphur banks, he and his guide, succeeded in reaching the base of Krabla, without meeting with any of those pools of hot water, which his guide so much dreaded, and after having ascended several eminences, he came suddenly in sight of a scene which

was abhorrent, and repulsive beyond conception. "At the bottom of a deep gulley, says he, lay a circular pool of liquid matter, at least 300 feet in circumference, from the middle of which, a vast column of the same black liquid was erupted with a loud, thundering noise; but being enveloped in smoke, to within about three feet of the surface of the pool, I could not form any idea of the height to which it rose."

"From every circumstance connected with the vast hollow in which the pool is situated, I could not but regard it as the remains of the crater; which, after having vomited immense quantities of volcanic matter, has loosened the adjacent parts of the mountain to such a degree, that they have fallen in, and left nothing but the boiling caldron to mark its site, and perpetuate, in faint adumbrations, the awful terrors of the scene. The surface of the pool may be about 700 feet below what appeared to be at present, the highest peak of Krabla, and about 200 feet below the height on which I stood."

"Having continued for some minutes to disgorge its muddy contents, the violent fury of the Spring evidently began to abate; and as the ground along the west side of the hollow seemed sufficiently solid, I got the guide to accompany me to the immediate precincts of the pool." * * * "Nearly about the centre of the pool, is the aperture whence the vast body of water, sulphur, and bluish black *bolus* is thrown up, and which is equal in diameter to the column of water ejected by the Great Geyser, at its strongest eruptions."

"The height of the jets varied greatly, rising on the first propulsions of the liquid, to about twelve feet, and continuing to ascend, as it were, by leaps, till they gained the highest point of elevation, which was about thirty feet, when they again abated much more rapidly than they rose, and after the spouting had ceased, the situation of the aperture was rendered visible only by a gentle ebullition, which distinguished it from the general surface of the pool. During my stay, which was upwards of an hour, the eruptions took place every five minutes, and lasted about two minutes and a half."

"I was always apprised of the approach of an erup-

tion, by a small jetter that broke forth from the same pool, a little to the east of the great one, and was evidently connected with it, as there was a continual bubbling in a direct line between them. While the eruption continued, a number of fine silver waves were thrown round to the sides of the pool, which was lined with a dark blue clay, left there by the subsiding of the waves."

"The above is an outline of the situation and general appearance of this wonderful pool, but its horrors are absolutely indescribable. To be conceived, they must be seen; and for my part, I am convinced that the awful impression they left on my mind, no length of time will ever be able to erase."

Valley of Smoke.—In another part of Iceland, Dr. Henderson visited a place called the "Valley of Smoke," from the great quantity of steam which constantly issues from the Hot Springs situated there.

"The principal Spring," says he, "is remarkable for its three apertures, the lowest of which, serves as a conduit for the boiling water, while the two that are situated a little higher up, answer the purpose of steam-pipes, through which the vapor makes its escape during the discharge of the water. This, of all the Springs I have seen in Iceland, most resembles a steam engine. When an eruption is over, it intermits, and the water sinks out of sight for the space of about 15 seconds; after which, the engine is again set in motion, the steam rushes out of the two apertures, with a loud hissing noise, and a considerable quantity of water is discharged."

At the distance of a mile further down the valley, "having cautiously leaped over a rivulet of boiling water," continues the author, "I took my station in front of the other Springs; but ere I was aware, I was nearly suffocated with heat, and dense vapors, which so closely surrounded me, that I could neither see my companion, nor how to make my escape from the spot on which I stood. At the distance of only a few yards before me, roared not fewer than sixteen boiling caldrons, the contents of which, raised in broken streams of various heights, were splashed about the margins, and ran with

great impetuosity, in numberless streamlets, down the precipice on which the Springs are situated.

Baths of Pfeffers.—The Warm Spring of Pfeffers, situated in the Alpine Mountains of the Canton of Glaris, in Switzerland, has been celebrated for many centuries, for its sanative virtues. The gorge in which this Spring is situated, and the features of the adjoining country, are, probably, on several accounts, the most extraordinary which the whole earth presents. This, therefore, must be an excuse for the length of the following description, which is abridged from "Switzerland Illustrated," by Dr. Beattie.

There is nothing, says he, in this country, nor probably in the whole confederacy, which strikes a foreigner with such astonishment, as the Baths of Pfeffers.

As medical compounds may be salubrious to the constitution, although offensive to the sense of taste, so nature, in the present instance, has shut up her salutiferous spring in a composition which must shock the eye, and excite the imagination of every pilgrim who would partake of its healing qualities. It is the golden fleece guarded by a frightful dragon—

"A fountain of health, in the bosom of horror."

The Spring was known, and appreciated at the early period of 1038, but owing to its extreme difficulty and danger of access, was soon neglected, and at last forgotten for nearly two centuries, and only turned to account after its *second* discovery in 1240, when a hunter, says the tradition, while risking his neck for the possession of a Raven's nest, saw the vapor oozing out of the abyss, and made known his discovery for the public benefit.

During the 14th century, the only means of access, were through a perforation in the rock, communicating with the Spring by ladders of ropes—a method of approach full of danger.

In about 1440, a bridge was constructed at the fearful height of 540 feet above the channel of the river Tamina, and 130 feet long; but this was entirely destroyed by fire, in 1639, and never re-built.

These thermal waters take their source in the gorge of the Tamina—the horrors of which, defy alike the power of imagination, and the pen of description. They are, after their kind, the most dismal, in point of situation, on which the human eye can gaze, and open to the stranger, a region of which, he feels that no adequate report had reached him; and compared with which, the wildest scenery of romance seems tamed, and softened down into simplicity. The very expressions to which we are accustomed to give utterance amidst the sublimer spectacles of nature, are here silenced by a sentiment of awe, which paralyzes the nerves of speech—shows us the poverty of words, compels us to halt, and gaze, and meditate in mute astonishment, and with feelings as new to ourselves, as the scenes by which they are called forth.

As we continue our approach, the depth of the ravine darkens below, the light from above diminishes, the attributes of chaos multiply, the ministers of death, so to speak, beset us on all sides,—cut off retreat, and seem hurrying us forward to the verge of primeval night.

The descent seems insecure and precipitous—on the opposite bank of the torrent, a space of fifty yards across, the shattered marble walls of the chasm shoot up vertically from the torrent's bed, to the height of 700 feet, losing their summits in the sky, sprinkled with pine, elm, and maple trees, and festooned here and there with the bright Alpine rose, clinging to the imperfect crevices, where no other vegetation can find nourishment.

The width of the gorge, at this point, is about ten yards, but it becomes narrower as it descends, while the lateral walls of rock, contorted, cleft, and torn into most extraordinary, and fantastic shapes, tower up to the height of several hundred feet, and then projecting forward, one towards the other, and rising as they contract, meet, at length, in form of a vast dome, the centre of which is little short of 300 feet in height. The depth of the gorge, is estimated at 700 feet, by 200 in breadth, but in some places it does not amount to more than a twentieth part of that extent.

The feeble and glimmering light, with which this gulf

is visited, even at noon day, gradually disappears, as we plunge downwards into the abyss, where the cold and dripping atmosphere, surcharged with moisture, chills the blood, and contributes not a little, to enhance the accumulated horrors of the place.

The Baths, built in 1704, consist of two principal houses, like barracks, joined together by corridors, 400 feet in length, affording accommodation for several hundred guests, who are not over fastidious on the score of lodging, and are willing to receive moderate comforts, on moderate terms.

The storms which break over this gorge, but without troubling its repose, are peculiarly grand and impressive, more particularly so during the night, when the thunders seem to answer one another from Alp to Alp, and the foaming cataracts, as they gush from the precipices, are illumined with flashes of lightning.

The longest day in this place, consists of five hours, the remaining nineteen being divided between glimmering night, and Tartarean darkness. At midsummer only, the sun is visible, from a quarter past nine, till four o'clock in the afternoon; in the end of July and August, from eleven to three, and in winter, from most parts, it is never seen at all.

The atmosphere here, is not subject to those sudden transitions, which so powerfully affect invalids in other situations. Walled in, on all sides, by marble ramparts, this retreat may well be compared with the well known property of some cathedrals, such as St. Peter's, which by their massive structure, embrace an atmosphere peculiar to themselves, the temperature of which, is so mild and equable, as often to surprise those who enter them at periods of atmospheric changes.

It is a remarkable fact, that when the plague of 1611 made such terrible ravages in the country, that whole villages were depopulated, and even cats, dogs, and birds, fell dead under the poisoned atmosphere, these Baths served as a perfect sanctuary to the refugees, with whom they were crowded, even during the winter, but never betrayed a symptom of contagion.

Healing properties of the Waters.—The healing pro-

perties to which these waters lay claim, are numerous, and are supported by the best of all authority—that of experience, and the testimony of a hundred generations. The springs are periodical, and appear, and disappear indefinitely, according to the peculiarities of the seasons. In summer, the supply varies from 100 to 200 gallons per minute.

The temperature at the fountain, is uniformly at 100°. The properties are not detected by color, taste, or smell; the water is exceedingly limped, and leaves no deposit, after being kept for years. It is employed in the double capacity of beverage and bath, and apportioned, under medical superintendence, to the complaint and constitution of the patient. The diseases in which it is chiefly employed, are rheumatism, and glandular, and cutaneous affections; but is looked upon as a general panacea for almost every complaint that flesh is heir to. The season for the Baths commences in June, and ends in September, when the springs begin to diminish, and disappear in October; in some instances, however, they continue to flow during the whole winter.

The specific gravity is 10.104, distilled water being 10.000. As it gushes from the source, a faint smell of sulphur is sometimes perceptible; to the touch, it is soapy, and it deposits on the rocks a bright yellow clayey sediment, which is used as a surgical dressing.

Composition.—The last analysis of the Waters of Pfeffers, gives the following results:

	Grains.
Muriate of Magnesia, and extractive matter,	0.16
Muriate of Soda, - - - -	0.21
Resinous substance, - - -	0.06
Sulphate of Soda, - - -	1.62
Sulphate of Magnesia, - - -	0.37
Carbonate of Lime, - - -	0.32
Carbonate of Magnesia, - -	0.87

One of the most curious objects, this place presents to the eye of the stranger, is the crane, by means of which, as a mechanical power, the daily supply of provisions is lowered from the rocks to the inn, a depth of 664 feet.

Temperature of the principal Warm Springs of Europe.

The following are most of the Warm Springs of Europe. Some of them have been known and celebrated ever since the historical era. Of the waters of Bath, in England, there is a tradition, that one of the ancient kings of that country, being expelled from his throne, cured himself of leprosy by washing in this Spring. When the Romans occupied England, inspired by their usual fondness for luxury and magnificence, they erected splendid baths at this place. The ruins of these monuments were discovered in 1755, twenty feet below the surface of the earth, near the centre of the present town.

The famous waters of Aix-la-Chapelle, were also known in the most ancient times, and were for a long period occupied by the Romans. They contain several saline compounds, and are employed for cutaneous, and visceral diseases.

Indeed, Warm Springs, in every part of the world, where they exist, have ever been considered among the greatest luxuries and blessings, and have always been employed as baths, whether they contained any medicinal virtues or not. Springs may be considered warm, when their temperatures are above 50°.

	Temperature.
Bristol, (England)	74°
Matlock, "	66
Buxton, "	82
Bath, "	116
Vichy, (France)	120
Carlsbad, (Bohemia)	165
Aix-la-Chapelle, (Flanders,)	143
Aix-les-Bains, (Savoy)	117
Leuk, (in the Haut Vallais)	126
Baregeo, (South of France)	120

The only Warm Springs found in the United States, are those in Bath County, Virginia, those on the Wachitta, in Arkansas, and that of New Lebanon, N. Y. Those of Wachitta, are said to be about 70 in number, their temperatures varying from 90° to 140°.

CAVERNS.

Subterranean Caverns, of greater or less extent, and depth, have been discovered in most parts of the world. In general, they are situated in calcareous, or limestone rocks, especially those of great extent, but are also found of smaller size, in primitive and transition rocks. The extent of some Caverns, is many miles, as that of Kentucky, which has been explored to the distance of 10 miles from its mouth. The depth of others is also enormous. That of Eldenhole, in the peak of Derbyshire, has been sounded to the depth of 9600 feet, or more than a mile and a half, without reaching the bottom; and the abyss near Frederickshall, in Norway, is so deep, that a stone, it is said, requires two minutes to reach the bottom, which, if it met with no interruption, would make its depth more than 20,000 feet, or upwards of three miles.

Cavern of Guacharo.—Humboldt has given a curious and interesting account, of a great Cavern in Cumana, in South America, called the Cave of Guacharo. So much do the inhabitants pride themselves in the possession of this Cavern, that it is a subject of almost never ending conversation, especially to strangers. It is said to be several leagues in length, and the natives sometimes call it a *mine of fat*, from the circumstance, that at certain seasons they take vast numbers of birds in it, the fat of which, they obtain for culinary purposes.

At the foot of the lofty mountain, Guacharo, says Humboldt, we were only 400 steps from the Cavern, without yet perceiving its entrance. The path winds like a river; at the last turning, we came suddenly before the immense opening of the grotto. The aspect is majestic, even to the eye of a traveller accustomed to the scenes of the Upper Alps. Nature, in every zone, follows immutable laws, in the distribution of rocks, in the exterior forms of mountains, and even in those tumultuous changes which the external crust of our globe has undergone. So great an uniformity, led me to believe, that the aspect of the Cavern of Caribe would differ little from what I

had observed in my former travels. The reality far exceeded my expectations. If the configuration of grottoes, the splendor of the stalactites, and all the phenomena of inorganic nature, present striking analogies, the majesty of equinoxial vegetation gives, at the same time, an individnal character to the aperture of the Cavern.

The Cavern of Guacharo is pierced in the vertical profile of a rock. The entrance is towards the south, and forms a vault 80 feet broad, and 72 feet high. The elevation is but a fifth less than the colonade of the Louvre. The rock which surmounts the grotto, is covered with gigantic trees, and various herbaceous species project from the clefts around the opening of the Cavern.

The light does not disappear before advancing 400, or 500 feet, when torches become necessary. As the darkness increases, the hoarse croakings of nocturnal birds begin to be heard; sounds which the natives think belong exclusively to these subterranean places.

"It is difficult to form an idea of the horrible noise occasioned by thousands of these birds, (the Guacharo) in the dark part of the Cavern, and which can only be compared to the croaking of our crows. The shrill and piercing cries of these birds, strike upon the vaults of the rocks, and are repeated by the echo in the depth of the Cavern. The Indians showed their nests, by fixing torches on the end of a long pole. These nests were 50 or 60 feet above our heads, in holes in the shape of funnels, with which the roof of the grotto is pierced like a sieve."

The Indians enter this cave once a year, near midsummer, armed with poles, by means of which, they destroy the greater part of the nests. At this season, several thousands of the birds are killed; and the old ones, to defend their brood, hover over the heads of their executioners, uttering terrible cries. The young birds are exceedingly fat, and this part is taken out, and preserved for use. The Guacharo quits the Cavern at night fall, especially when the moon shines. This is almost the only fruit, or seed eating bird, which is nocturnal in its habits; the Owl, and other birds of the night, living on flesh.

"We followed," continues the author, "as we contin-

ued our progress through the Cavern, the banks of the small river which issues from it, and is from twenty to thirty feet wide. We walked on the banks, as far as the hills formed of calcareous incrustations permitted us, and learned with surprise, that this subterranean rivulet is the origin of the river Caribe, which, at a few leagues distance, is navigable for canoes."

"This grotto, preserves the same north and south direction, and the same heigth and breadth, to the distance of about 1400 feet. I have never seen a cavern of such uniform, and regular construction."

Stalactites, and Stalagmites.—In most limestone caverns, the percolation of the water through the rocks, give rise to those calcareous formations, called *Stalactites*, and *Stalagmites*. The first hang like icicles from the roof of the cave, and the second forms by the dropping of the water from the first. These productions are constantly forming, so that when one is broken off, it will, after a while, be reproduced. The manner of their production, is easily explained. The water, as it is strained through the rock, dissolves a portion of the lime, and as it descends, and becomes exposed to the air, a portion of the fluid is evaporated, leaving the lime in its solid form. It is often the case, in Caverns, that the water, while forming the stalactite at the roof, is also producing the stalagmite at the bottom, by dripping from the point of the first, so that the two meet, and form columns, or pillars, from the floor to the ceiling.

Grotto of Antiparos.—One of the most celebrated Caverns of this kind, is the Grotto of Antiparos, in the Grecian Archipelago, which is mentioned by the earliest writers, as a great natural curiosity. The passage, at its entrance, is studded with polished stalactites, which, by the light of the torches which the visiters carry, glitter in a manner to astonish, and delight the spectator. Having passed this entrance, the adventurer is let down several precipices, by means of ropes, to the depth of 1500 feet, when he reaches the principal Cavern, which is a magnificent room 360 feet long, 340 wide, and 180 feet high.

The roof is adorned with enormous stalactites, many of which are 40 feet long, and several feet in diameter, appearing like great icicles, attached to the vaulted ceiling. In some parts, immense columns descend from the roof to the floor, and in others, there are appearances like those of brooks and trees, turned into stone.

Nearly all limestone countries contain more or less caves, where stalactites are formed. In the Southern and Western States, many Caverns of this kind, some of them of vast size, have been long known, and are described in various publications.

Caverns containing Bones.—Vast quantities of the bones of animals, and in some instances, those of men, have been discovered in the subterranean Caverns of various countries. In some instances, these appear to have been the residences of beasts of prey, the bones being the remains of animals carried there for the subsistence of the former inhabitants. In others, the animals, and men, appear to have fallen in, by an open fissure from the surface; and in others still, neither of these suppositions will account for the phenomena observed; and the manner in which these relicts came where they are now found, remains a mystery, which no one has been able satisfactorily to explain.

In the mountains of Hungary and Germany, it has been long known, that there are caves containing vast quantities of the bones and teeth of carnivorous animals. These organic remains are nearly in the same state, and appear to have belonged to similar species of animals, to the extent of more than 100 leagues of country. About three fourths of these bones belonged to several species of bears now extinct, and about two thirds of the remainder belonged to an unknown species of hyena, and a smaller number to a species of lion, or tiger, or to the wolf or dog.

The bones are found scattered, and detached, partly broken, but never rounded by attrition, as though they had been drifted along the surface of the earth by water. They are not petrified, but preserve their animal matter. They lie embedded in earth, which, in some instances, appears to have been formed, in a great

measure, by the decay of bones, and other animal remains.

The most remarkable of these Caverns, is that of Gaylenreuth, in Bavaria. This consists of several apartments, varying in height from ten to forty feet, which are connected together by narrow passages. In some of these caves, the animal earth intermingled with bones, is more than ten feet deep; and according to the accounts of eye witnesses, such is its quantity, that many hundred wagon loads might be obtained. This is every where mixed with bones, and the teeth of bears, wolves, and other animals, in such abundance, that bushels of teeth might be gathered.

Cavern of Adelsberg.—There is a Cavern, or series of Caverns, at Adelsberg, in Carniola, much larger than those of Germany. The individual caves are of various dimensions, connected by passages, the whole series extending about nine miles in a right line, at which distance there is a lake, which prevents further access.

The floors of these Caverns are covered with indurated clay, in which is embedded the bones and teeth of bears, and other carnivorous animals, of similar species to those found in Germany and Hungary.

The river Pinka, a considerable stream, is lost in this Cavern, terminating in a subterranean lake, from which another river emerges, on the northern side, called Unz, or, perhaps more properly, the same river, under a different name. In many parts of this Cavern, the bones are covered with stalagmite, to considerable depths.

The Adelsberg cave has been known from ancient times, and formerly, the bones which it contained, were dug up and sold to the ignorant for medicine, under the name of fossil *Unicorns' horns.* At one time, this was a considerable article of commerce, but it is hoped, that at the present day, the general acquisition of knowledge has done away such a barbarian custom.

Caves of Palermo.—Near the city of Palermo, in Sicily, there is a Cavern, or Grotto, called San Ciro, about which, much curious information has been published. This cave is 10 feet high, and 20 feet wide, and contained in a rock of secondary limestone.

It is situated near the sea shore, and it is evident from appearances, that the water of the ocean once occupied the cave itself, as it contains marine shells, and water worn pebbles. A still stronger evidence of this exists in the perforations, which remain in the sides of the cave, of a species of shell fish, called *lithodomi*, which have the power of boring into limestone rocks. These fish are exclusive inhabitants of salt water, and hence the positive proof that the cave once contained it, though it is now elevated nearly 180 feet above the level of the sea.

An immense number of bones, a part of them rolled, and water worn, was found in this cave. So enormous, indeed, was the quantity, that ship loads were exported in 1829 and 1830, in the hope of their retaining a sufficient quantity of gelatine to serve for the refining of sugar, for which, however, they proved useless. These bones chiefly belonged to the mammoth, the hippopotamus, and several species of deer.

It is no easy matter to account satisfactorily, for such phenomena. It is certain, that the animals, whose bones are found there, could not have occupied this Cavern while it was under the sea, and equally so, that they could not, in such numbers, have fallen through a fissure from the surface. The most probable conjecture, therefore, is, that this cave was once a den occupied by the hyena, an animal which, it is known, lives chiefly upon the bones of other animals, and which it drags into Caverns of the earth. Subsequently the land, in that volcanic region, probably by the agency of an earthquake, must have sunk down, so as to have been overflown by the sea, which accounts for the marine productions found in it. Afterwards, by another earthquake, we must suppose that the land was again elevated to its present situation. This is, perhaps, the most reasonable conjecture, by which the appearances of this cave can be accounted for, and yet it is difficult to reconcile the vast number of these bones with such a hypothesis; nor can we readily conceive how animals of the size of the hyena, could convey the bones of the huge mammoth into their dens, though it must be remembered that only separate bones, and not whole skeletons, were found.